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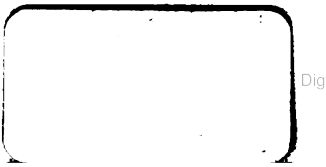

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MATERIA MEDICA

AND

THERAPEUTICS

INORGANIC SUBSTANCES

BY

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MATERIA MEDICA

AND

THERAPEUTICS.

INORGANIC SUBSTANCES.

ARGENTUM—SILVER, Ag,=108.

THIS metal occurs pure, but more often in alloy, as with lead (galena), or combined with sulphur (argentite), chlorine (horn silver), and with iodine, bromine, etc.

Refined silver is placed in the Pharmacopœia as a source of the nitrate, but is otherwise used only in the form of silver-leaf as a coating for pills: its officinal compounds are the nitrate and the oxide.

ARGENTI NITRAS—NITRATE OF SILVER, $AgNO_3$,=170.

Prepared by crystallization from a solution of pure silver in dilute nitric acid: when fused and solidified in moulds, it constitutes the small pencils known as "lunar caustic."

CHARACTERS AND TESTS.—The crystals are tabular and colorless, and form a neutral solution with distilled water: sp. gr. 4.3. They are soluble in four parts of rectified spirit; when pure they do not blacken on mere exposure to light, but do so, and readily decompose, on continued contact with any organic substance.

An aqueous solution of the nitrate is precipitated by any soluble chloride, a characteristic curdy-white chloride of silver being formed, which becomes dark on exposure to the air: it is soluble in ammonia, insoluble in nitric acid. A black sulphide of silver is precipitated from a solution of the nitrate by passing through it sulphuretted hydrogen.

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ARGENTI OXIDUM—OXIDE OF SILVER, Ag_2O,=232.

PREPARATION.—By precipitation from a solution of the nitrate by means of lime-water.

CHARACTERS AND TESTS.—Occurs as an olive-brown powder: sp. gr. 7.2. It is reduced to the metallic state by a red heat, is soluble in ammonia and in nitric acid, but slightly soluble in water, to which it gives a metallic taste and an alkaline reaction.

Chloride of Silver, AgCl (not officinal).—Readily obtained by decomposing any silver salt with hydrochloric acid, when it precipitates as a white caseous powder (horn silver): it darkens on exposure, and is soluble only in ammonia and in hydrochloric acid.

The *Ammonio-chloride* (not officinal) is an unstable salt soluble in water. The *Chloro-albuminate*, the *iodide*, and the *double iodide* of silver and potash are soluble salts that do not coagulate albumen. The *hyposulphite* of soda and silver is astringent and less irritant than the nitrate; the *cyanide* is said to be more readily absorbed.

ABSORPTION AND ELIMINATION.—Nitrate of silver, when taken into the stomach, forms with mucus and epithelium a thin pellicle, which, to some extent, hinders absorption. The chemical change which all silver salts undergo, more or less, when in contact with the gastric secretions, results in the formation of a double chloride of silver and sodium, and although *ordinary* chloride of silver is insoluble in water, this *double* chloride is readily dissolved by the gastric fluids; its combination with peptones is also soluble (Bogolowsky: Virchow's *Archiv*, xlvi., 1869, and others). As chloride and albuminate it probably passes into the blood, and circulates with it, being retained in solution by the alkaline serum (Rouget), though Frommann thought that it separated in the molecular form (*Archiv für Path. Anat.*, 1859). Dragendorff considers that the chemical changes occur chiefly in the duodenum, and that the gastric juice being here neutralized by the bile, silver sulphide is ultimately formed: certainly, of unabsorbed silver compounds, the greater part passes off by the bowel as sulphuret, coloring gray or black the mucous membrane and the fæces. More of the salt will be absorbed if given in solution in distilled water on an empty stomach, than when given in pill in the ordinary manner. Riemer has shown that in pills (? bread) four-fifths of the silver nitrate is decomposed even before administration (*Archiv der Heilk.*, xvi., 1875). The same observer also sought to prove that molecules of silver pass in a mechanical manner through the intestinal walls, but Fragstein could detect no absorption of freshly precipitated silver-chloride introduced into the intestine of frogs (*Berlin. Klin. Woch.*, 1877). Orfila and Heller failed to find traces of silver in the blood after its administration; but Orfila and Panizza found it in the urine (Husemann), and Cloez iso-

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lated a globule of the metal from the collected urine of several patients at the Salpêtrière. It has been found also in the liver and the bile, and some is eliminated by the cutaneous glands. Rozsahezzi found it in the intestinal contents after its hypodermic injection (*Archiv Klebs*, 1878).

The most important practical point is, that elimination of silver salts by any channel occurs but *slowly*, so that if they are taken continuously for a long time, the reduced metal becomes deposited in the tissues, giving them a dark-gray coloration, known as "*argyria*." The gums show the earliest indication of this condition by a bluish line (which is darker than that produced by lead), and parts exposed to light show the color more than others—thus the lunula of the nail (Falck), the eyes, the face and hands are affected early; the deposit is in the true skin (corium). Neumann has recently examined minutely a portion of the skin of a man who had partial argyria from frequent applications of nitrate to reduce large papillæ on his tongue: dark granules of the metal were found in the upper part of the cutis, in the wall of the sweat-gland, in the connective tissue of hair-follicles, in sarcolemma, neurilemma, and the middle coat of vessels; none were deposited in the epidermis, the mucous layer, or the epithelial lining of hair-follicles or sweat-glands (*Medical Record*, 1877). That the coloring is partly due to the influence of light is shown by cases in which the viscera were seen to darken after exposure (Huet, Frommann, Fragstein), but the more active circulation of exposed parts is another factor in their coloration.

If the drug be stopped on the earliest appearance of affection of the gums, the general discoloration is not likely to occur. This was shown in the case of a woman who took nitrate of silver for two months—at first ⅛ gr., and later 2 gr. daily—swelling and redness of gums, with a purple line at the edges, appeared, and there was much tenderness of mouth with metallic odor of breath; but, on ceasing the medicine, these symptoms subsided (*Bulletin de Thérapeutique*, v., 1871, p. 86). In other cases when large quantities have been taken, every part of the body has been affected. Van Geuns reports that a youth took about ½ gr. of the nitrate daily (with occasional intervals), from his fourteenth to his nineteenth year, none afterward: he died of phthisis at the age of thirty-five, and not only was the skin colored, but also the cerebral and spinal membranes, the laryngeal and bronchial membranes, the peritoneum, the papillæ, and malpighian bodies of the kidney, the marrow, and the bones; the nervous, the hepatic, and other parts of the renal tissue were reported normal. Heynsius concluded on analysis that the dark granules were not chloride of silver (for ammonia did not affect them), nor oxide, but minutely divided particles of the reduced metal, and this conclusion is now generally accepted (Abstract, *Dublin Quarterly Journal*, August, 1858).

Charcot has recorded the presence of silver round the renal glomeruli and in the Malpighian pyramids, and Liouville has made a similar obser-

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vation as to the kidneys, and also as to the choroid plexus of a patient who had taken 110 gr. in the course of nine months, three years before his death. Virchow recorded renal argyria after absorption from connective tissue. Several cases are quoted by Stillé, by Sieveking, by Riemer, and others (Schmidt's *Jahrbucher*, ii., 1875, p. 295): many of them seem to have died of phthisis several years after the administration.

Argyria may even follow *local* applications of nitrate, as in the case of a girl whose throat was repeatedly cauterized—perhaps fifty times in the course of twelve months; she is said to have swallowed the products (*Gazette de Paris*, xxviii., 1874). It has occurred also after tracheotomy, the wound having been pencilled "for a long time" ("Dictionary Encyclopedia," v., vi.), and in a woman after the continued use of a nitrate pomade for dyeing the hair.

It is important to ascertain, if possible, what quantity of the drug is liable to produce coloration, and the time during which its use may be safely continued. The actual amount deposited is certainly very small: Versmann found only 0.047 per cent. in the liver in a well-marked case, but Krahmer estimated that there must be the residue of at least 1 oz. of the salt to cause discoloration: from 3 to 5 oz. are mentioned as the quantities taken in several instances, but, judging from Liouville's case, it is probable that less than 1 oz. might suffice. Six weeks has been named as a safe limit of time for the continued administration of the drug, and I should think it almost impossible for any ordinary dose to produce bad results within that period.

The sulphide was the salt used in the first authentic recorded case of coloration (Weigel): the iodide is said to be free from this risk, and no case has been traced to it, but Husemann considers this as accidental: the double iodide of silver and potash is also regarded as less liable to be deposited (Delioux).

Physiological Action (External).—If moistened nitrate of silver be applied lightly to the skin, it combines with albuminous material, and leaves a white stain, which soon darkens on exposure to air or light, because of its reduction to metallic silver; the darkened epidermis peels off in a few days' time. Strong applications, such as the moistened stick, or solutions of 1 to 2 dr. in the ounce, cause more or less severe burning pain, and, in delicate skins, vesication. On mucous membranes, or moist denuded surfaces, a whitish layer is formed by combination with chlorides and albuminous secretion: this layer soon becomes gray and then dark, and when it peels off may leave the part tender. Applied to a suppurating surface, the solid nitrate combines with the purulent secretions to form a grayish layer, stimulates the healing process, and causes some burning pain and redness near the part: when the superficial eschar falls, as it does in twenty-four to forty-eight hours, fresh and healthy

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granulations are usually found on the wound. The action cannot extend deeply because of the pellicle which is formed, and the so-called "caustic" effect of nitrate of silver must be distinguished from that of destructive agents, such as potash or acids, for it is produced by coagulating and hardening organic tissues, rather than by destroying them. The affinity of the salt for albumen, and its forming with it an insoluble compound, explain most of the local effects of the nitrate.[1]

A solution of about 20 gr. per ounce brushed over a moderately inflamed part not only discolors it, but reduces its size, controlling inflammation, and constringing the blood-vessels. The conjunctiva has sometimes been discolored by continuous use (to it) of medicinal drops, and in this and other very sensitive parts, such as the schneiderian, buccal, or urethral membranes, much pain, irritation, and increased secretion follow the use of strong solutions. Weak solutions (1 to 3 gr. in 1 oz.) have an astringent and slightly stimulant action, and do not cause pain except to a delicate membrane like the conjunctiva. Silver solutions possess, also, antiseptic power, in degree somewhat proportionate to their strength, and dependent in part, though not wholly, on coagulation of albumen.

Physiological Action (Internal).— *Digestive System.*— Small doses of the oxide (¼ to ½ gr.), and still smaller ones of the nitrate of silver (⅛ gr.), are usually well borne by the stomach; but the latter salt produces a metallic, bitter taste in the mouth, and, unless well diluted, causes burning sensations in the fauces. In ½ to 1-gr. doses it is apt to induce nausea or vomiting, pain, and diarrhœa; headache and vertigo are usual accompaniments. The continued use of smaller medicinal doses impairs the appetite, and may induce intestinal catarrh and hemorrhage. Any amount over 4 or 5 gr. would be usually rejected by vomiting, otherwise it would excite inflammation. After death from toxic doses, the gastro-intestinal membrane has been found soft, eroded, or covered with gray patches. In chronic cases the muscular and mucous coats become hardened and thickened.

Nervous System.—The main point determined by modern investigation into the action of silver compounds is their special effect upon the nervous system. The best experiments have been made upon animals by hypodermic injection of hyposulphites and albuminates of silver, which do not coagulate albumen. Charcot and Ball reported, as usual results of such injection, paraplegia and paresis of pulmonary nerves, probably reflex in character, leading to profuse bronchial secretion and asphyxia (*Gazette Méd.*, 1864). Rouget found that in mammalia, small doses

[1] The chemical formula of the silver-albumen compound seems to vary under different conditions. Lassaigne gives 84.5 per cent. albumen, 15.5 of nitric oxide of silver; Mulder, 16 of the latter in one experiment, 8.9 in another; Krahmer, nearly 12 per cent. Delioux pointed out that the affinity of the nitrate for albumen is greater than it is for chlorine (Husemann).

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caused excitement somewhat like strychnia; toxic doses induced convulsion and asphyxia. Batrachians got convulsions or tetanic spasm with suspension of voluntary movement, of reflex action, and of respiration, while circulation continued; weakness, torpor, somnolence, and paralysis also occurred in various degrees (*Archives de Physiol.*, 1873). Professor Curci, experimenting on animals with hypodermic injections of hyposulphite of silver, reports that at first they stimulate sensory nerves, and through them the posterior columns of the spinal cord, so that sensibility to impressions and reflex excitability are increased—this condition extends more or less to the motor nerve-tracts, muscular irritability is heightened, and tetanus may be produced: afterward follows a secondary effect of paresis of sensory nerve-centres, and of those connected with respiration; ultimately reflex action is arrested, and respiration and circulation cease. We may accept these facts without assenting to the conclusions drawn by Professor Curci from them, viz., that since silver compounds ultimately paralyze, they cannot be of service in paralysis, myelitis, etc., but are only indicated in spasmodic disorders, especially such as affect respiration (*Medical Record*, 1877).

Bogolowsky, in his experiments, sometimes found the spinal cord so far affected that the bladder became greatly distended.

An exceptional illustration of the nerve-effects of the drug on man, may be found in the case of a man accustomed for twelve months to dye his hair and beard with a strong solution, and who suffered general weakness, confusion of thought, loss of memory, tinnitus aurium, and defective sight, which symptoms ceased soon after stopping the dye (Bresgen: Schmidt's *Jahrbucher*, 1874, Bd. clxii.). Within my own experience I have known men suffering from the same cause, with giddiness, vertigo, and marked nerve-depression, amounting almost to melancholia, and recovering quickly after ceasing the application. Convulsions occur in children after toxic doses of the nitrate, but they are probably reflex—*i.e.*, dependent upon gastric irritation (*British Medical Journal*, i., 1871).

Circulatory System.—After intravenous injections of silver salts, the blood has been found dark, pitchy, impaired as to coagulating power, and containing small crystals, and "whitish granulations," which were supposed to be chloride of silver (Rabuteau), but are more probably hæmatin and protein (Rouget). Ecchymoses have occurred, and, together with the asphyxia and increased bronchial secretion, have been attributed to the altered chemical condition of blood (Krahmer, Monograph, 1845), but such alteration is not produced (in acute form) by silver administered in any other way than by direct injection into the blood. Even toxic doses given in other ways do not alter that fluid beyond some lessened coloration of the corpuscles and increase of fibrin (Bogolowsky, loc. cit., Rouget); the spectrum remains normal. But after the continuous use of full doses of albuminate or phosphate of silver, the blood-condition

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certainly becomes impaired; the fluid is found to be thinner and darker, and it tends to stagnate in, and transude through, the vessels, while the corpuscles part with hæmo-globulin, and become pale, transparent, and angular or oval, with projections: according to Bogolowsky, they do not contain silver, as sometimes asserted.

Sudden arrest of the heart's action, as well as asphyxia with profuse bronchial secretion, were symptoms noted by Charcot and Ball after injections of silver nitrate into the veins of animals. Rabuteau, arguing from the same results, considered the drug to be a "cardiac poison," but it is clear that when thus injected directly into the circulation, the production of thrombosis or embolism may complicate and obscure the special effects of any substance. Rouget found that after hypodermic injection of toxic doses in the lower animals, the heart continued beating after respiration had ceased—*i.e.*, it was not "poisoned;" nor is there any clinical evidence of the salt depressing the circulation, unless in a secondary manner during irritant or chronic poisoning.

Respiratory System.—Orfila first described asphyxia as a result of injecting silver nitrate into the veins, and after death he found partial consolidation of the lungs, and excessive secretion in the bronchial tubes (Toxicology). Several observers have corroborated these results, and it has been a question whether they are mainly mechanical from thrombosis, etc., or reflex effects of lung-irritation (Charcot), or dependent upon direct irritation and paresis of the respiratory centre in the bulb, and of the neighboring vaso-motor centre. The recent observations of Rouget point to the latter conclusion. He found that in most animals urgent dyspnœa occurred, and, post-mortem, the lungs proved to be healthy in texture, but much contracted in volume—the muscular tissue of the bronchi being in a state of spasm similar to that of asthma. In adult specimens of only one order of animals (carnivora) did he find the excessive secretion described by Orfila, and he considered that only in these were the vaso-motor centres affected. That the main effect is exerted on the central rather than on peripheral nerve-elements he further supported by showing that nerves and muscles retained electric excitability after death. Still more recent observations by Rozsahezzi on rabbits show that in chronic poisoning by silver there is constantly hyperæmia of laryngeal and tracheal membranes, also of the lungs, and in these organs often œdema was found, with congestion, ecchymoses, effusions, cheesy masses, and sometimes a condition resembling phthisis (*Archiv Klebs*, August, 1878).

Nutrition.—Krahmer concluded from observations on himself, that the presence of silver in the system lessened oxygenation and the excretion of urea, of uric acid, and of the watery constituents of urine; the non-nitrogenous elements were, however, increased, and the sp. gr. rendered higher. If the administration of silver salts be continued beyond

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a certain point, cachexia sets in, appetite and digestion are impaired, catarrh and effusions take place, the temperature is lowered, and the action of the heart and lungs weakened. The general debility and emaciation are mainly dependent upon gastric irritation, but the drug seems to exert a special "alterative effect" on tissue-change. Dr. H. Wood classes it with "mineral astringents," Dr. Bartholow with "agents increasing waste," but I think it better placed among those that "moderate or retard nutritive processes" (Rabuteau). The recent observations of Rozsahezzi show a very marked diminution of tissue-change and of weight, under the continued influence of small doses of nitrate. This occurred even while the animal was taking a good amount of food, and when no increased excretion could account for the loss; he thinks it indirect from impaired blood and muscle-condition.

He finds (as opposed to Bogolowsky) that small doses cause a rise in temperature, but agrees with Falck that large ones lower it.

When death has followed the long-continued use of the drug, the epithelial structures, and the solid tissues generally—the liver, heart, muscles, kidneys, etc.—have been found in a state of "cloudy swelling" and fatty degeneration, and the metal has been detected in most parts of the body.

Fatal Dose (*Acute Poisoning*).—This varies with the gastric condition, period of vomiting, and of treatment, etc.: 30 gr. of nitrate have caused death in one case, while 1 oz. has failed to do so in another (that of Poumarède). Large doses have been neutralized by excess of natural mucus, or of albuminous food.

Synergists.—As regards local effects, the nitrate is allied with irritants and caustics, such as iodine and arsenic. In its general action, especially in therapeutical doses, a resemblance may also be found with these medicines as well as with compounds of chlorine, bromine, and salts of bismuth, and in a less degree, of zinc. Some analogy with strychnia has been traced (Charcot).

Antagonists and Incompatibles.—Sulphuric, hydrochloric, and tartaric acids and their compounds are chemically incompatible: also alkalies and their carbonates, astringent infusions, and lime-water; also creosote (*v.* p. 24). All soluble chlorides and cyanides are incompatible, since they precipitate an insoluble chloride of silver; most natural waters do so because they contain common salt: this salt is the best antidote to poisonous doses of the drug, and should be given freely so as to cause emesis as well as to neutralize the poison.

Therapeutical Action (External).—Nitrate of silver may be applied either (1) as a caustic, (2) astringent and alterative, (3) counter-irritant, or (4) as a direct irritant.

1. *Caustic.—Lupus.*—In cases of tubercular and ulcerating lupus the "lunar caustic" is sometimes suitable, and in the hands of Hebra, Neu-

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mann, and others, has given good results. No ordinary application or simple pencilling will be of any service, for it will not extend deeply enough, but a well-pointed "stick" should be firmly pressed into the soft tissue, in various directions and until hard tissue is met with: this is an extremely painful process, and in my experience can seldom be thoroughly done except under chloroform. As a rule, I prefer the nitrates of mercury or of zinc, but silver has the advantage sometimes where the face is affected, because its action can be so precisely limited to the diseased part, and does not cause so marked a cicatrix. Dr. Piffard recommends fine needles to be coated with the caustic and passed into the growth, finding this to be less painful than Hebra's method. Soothing applications, such as poultices and lead lotions, should be made after the cauterization, which may require repetition once or even twice weekly for some time. M. Claude specially recommends the double iodide of silver and potash (internally) in lupus and skin-disorders.

Warty Growths—Corns, etc.—The use of the stick-nitrate for destruction of these growths is familiar in practice, and is safe and painless, though not very quick in its results, for only a thin layer can be acted upon at each application: the part should be thoroughly softened and pared before the remedy is applied.

Carcinoma.—For the removal of cancerous growths, Thiersch has employed injections into their substance of solutions of 1 part of nitrate in 2,000 or 3,000 parts of water; this is followed by a similar injection of dilute chloride of sodium (1 in 1,000), and is said to cause quick disintegration and wasting of the morbid tissue. There is some independent confirmation of his results, but usually suppuration and sloughing have occurred—an effect which Thiersch did not intend (*Archives Générale*, January, 1867). I am not aware that the method has been extensively tried.

Poisoned and Dissection Wounds.—In such wounds a liquid and penetrating caustic, like nitric acid or potash, is more thorough in its effects, but nitrate of silver, being portable and at hand, has often been employed with good result; its antiseptic power is a recommendation. Mr. Youatt reports that he was bitten several times by rabid animals, and after a free use of this remedy had no ill results; but the degree of security given must vary with the thoroughness and time of the application.

Variolous and other Pustules.—Lunar caustic has proved useful sometimes in aborting purulent formations. The absence of pitting after small-pox being dependent upon the small size and limited inflammation of the pustules, Velpeau and others have endeavored to secure such a result by puncturing the vesicle on the third or fourth day, and touching the interior with a fine point of the nitrate; and if well carried out this plan has often succeeded. It is painful, tedious, and not free from

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danger, but the plan devised by Dr. F. Bowen is an improvement upon it, and is much more feasible: the vesicle is to be punctured with a fine needle dipped in a solution of the salt (20 gr. to 1 oz.); a nurse can do this quite well. In one case all the parts thus treated recovered perfectly, while the vesicles that were untouched left deep scars (quoted by Ringer). Mr. Higginbottom recommends painting of the face with the same strong solution that he used for erysipelas (80 gr. to ½ oz.), but this is too painful for ordinary use.

Molluscum Contagiosum.—The rounded, white, firm tumors of this malady are efficiently treated by evacuating their contents and applying nitrate of silver to the interior, as above described for variola.

Chancre.—Opinions have differed as to the possibility of preventing venereal infection by applications of nitrate to the sore soon after its appearance; authorities in favor of such practice are to be found among earlier writers, but modern opinion is decidedly against it. Hunter, Ricord, and Acton (writing in 1846) agree in stating that if the commencing chancre, the vesicle or pustule be thoroughly cauterized within three to five days of its origin the cure is rapid, and systemic infection very rare; but they agree also that if the sore be indurated no effect is produced, so that some of the cases they relied upon were probably "soft and non-infecting chancre:" on the other hand, Diday, Langston Parker, and others, have thus destroyed chancres within a few hours of their appearance, and yet an indurated sore and secondary symptoms have followed. We must conclude that cauterization of a true Hunterian chancre at any stage will not prevent its development or the occurrence of secondary symptoms.

Early cauterization of soft chancres will, however, sometimes cause rapid healing, and is a good treatment for sloughing or rapid spreading; but it is very painful, and the sore will usually heal under simple treatment. In syphilitic ulcers of the leg I have seen solid gelatinous fungating growths, which are well treated locally by pushing in a point of caustic and breaking them down freely with it, as already described under lupus. For syphilitic cracks, fissures, and ulcers on tongue and cheeks, the solid nitrate applied daily is very useful.

Granulations.—A minor degree of the caustic action of nitrate of silver will repress exuberant granulations in wounds; they should be pencilled every day or every second day.

2. *Astringent and Alterative.*—By the latter term we mean to express the modifying effect exerted on tissues, and especially on mucous membranes, whereby an unhealthy condition, usually inflammatory in its nature, is subdued, and healthy action is set up in its place. Trousseau taught that this effect is due to the new agent (nitrate of silver) causing a more powerful inflammation than the original one which it displaces, afterward itself subsiding; and this idea he developed at length under

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the term, "médication irritante substitutive" ("Materia Médica," i., 537), but we cannot prove the occurrence of any substitutive inflammation of this kind. We refer the effects of the remedy partly to its known physical properties of constricting vessels, of coagulating and disinfecting secretion, and of forming an adherent protective membrane; also, in certain conditions, *e.g.*, in ulceration, the vessels immediately acted on being constringed, those in the neighborhood receive a better supply of blood, and the processes of repair are quickened. The remedial power which is special to the drug, which distinguishes it from other astringents, and by which it modifies nutritive processes, we can only express by the term alterative.

In many forms of disorder accompanied by *discharge*, whether hemorrhagic, mucous, serous, or purulent, the nitrate, either solid or in injection or spray, is very valuable. (Delioux recommends the hyposulphite of soda and silver as equally astringent and less irritant.)

Hemorrhage.—In cases of continued oozing from small points in the skin or mucous membranes, such as occurs after leech-bites, a finely-pointed stick of nitrate firmly pressed on the part is a good astringent. In bleeding from the mucous membrane of the bladder, such as accompanies vesical tumor, injections should be made, beginning with weak solutions, and increasing the strength by degrees if necessary. Mr. Christopher Heath speaks highly of this plan, and I have seen several instances of its successful use in his hands.

Chronic Cystitis.—After washing out the bladder, a solution containing 1 to 2 gr. in 1 oz. of distilled water should be injected and allowed to remain for some minutes, or until micturition occurs; this lessens the muco-purulent ropy secretion from the vesical membrane: Mr. Reeves has used with success 20 gr. in 1 oz. (*Lancet*, i., 1853).

Gonorrhœa.—At the commencement an injection containing 30 or even 60 gr. to the ounce has sometimes succeeded in aborting the malady, but it causes severe pain, and may lead to serious inflammation. In the female, a similar solution applied thoroughly, per speculum, to the vagina, has given better results, and offers less risk on account of the anatomical conditions; but, as a rule, the frequent use of a weaker solution is more advisable. I recommend, so soon as the acute inflammatory stage begins to subside, an injection containing ½ to 1 gr. in the ounce every three or four hours; or sometimes a strength of only 1 gr. in 8 oz., to be injected every half-hour for the first eight hours, and afterward every four hours until cure is effected, which should be in twenty-four to forty-eight hours. I have had most excellent results in many obstinate cases from this method; it should not be wholly omitted at the end of forty-eight hours, but used once, or twice, or, if the discharge continues, a little oftener for the following two or three days.

Balanitis.—Gonorrhœal inflammation of the glans penis is effectually

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treated by the frequent use of a weak lotion (1 gr. in 1 oz.) in addition to light pencilling with the solid stick.

Spermatorrhœa.—The treatment by local application of a strong solution to the prostatic urethra in the neighborhood of the openings of the seminal ducts was strongly commended by Lallemand, but his statements are exaggerated; it is useful sometimes, but should not be employed without due consideration: I have seen serious consequences follow it.

Leucorrhœa.—Injections of silver nitrate have been found effectual in the vaginal form of this disorder, the strength of application being proportioned to the duration of the malady: a drawback to its use is the staining of linen. (There are several varieties of leucorrhœa, and each must be treated on its own merits, as some will require internal remedies as well as injections—the checking of discharge by this or other astringents is only one part of successful treatment.)

In *uterine* leucorrhœa the discharge is glairy and stiffens the linen, and is accompanied with distinct suffering. It is usually connected with cervicitis or endometritis, and in chronic stages, especially when the os uteri is patulous, solutions, and even the solid nitrate, have been passed into the uterine cavity with good result (Dr. Henry Bennet): this, however, has led to some abuse of the remedy, and I have seen very painful symptoms connected with induration of the cervix and narrowing of the canal as a consequence of too prolonged a course of cauterization.

Granular Erosion of Cervix (formerly known as *ulceration*).—The nitrate has been much used in this condition, but the solid salt can exercise only a limited influence. In chronic cases, where the part is enlarged, and the epithelium so long absent that the bared villi resemble granulations, I have found benefit from recently prepared iodide of silver, as recommended by Dr. Henry Wright.[1] All mechanical causes of erosion of cervix, such as impacted fæces, must be considered, and if present, treated at the same time.

Real *ulceration* of the cervix, as distinguished from erosion, is usually connected with syphilis, struma, or malignant disease, and although the nitrate has been often used for it, more potent remedies, such as the acid nitrate of mercury, are really required.

Ulceration.—When an ordinary ulcerated surface is discharging freely, a lotion of moderate strength is usually more suitable than the solid nitrate, because it does not involve confinement of discharge under a limiting membrane (though, indeed, such membrane may be punctured if necessary).

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[1] To a little of the strong silver solution (3 j. in ℥ j.) a few drops of tinct. iod. are added, and the iodide of silver precipitates at once in white flakes, which should be quickly applied—through the speculum (Uterine Disorders, p. 260).

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The best use of the solid stick is made in indolent ulcers with pale small granulations, and but slight discharge. The remedy should be lightly applied over the central parts, avoiding the new tissue at the margins, and under this stimulus, and the protection of the film which is formed, healing will be much quickened. The brittle stick nitrate is superior to the prepared points of "lunar caustic," for it is more soluble. Cuthill insists on the importance of stimulating an ulcer rather by dots and lines of silver nitrate than by coating its whole surface, better exit for discharge being thus given (*Edinburgh Medical Journal*, 1877).

Purulent Ophthalmia.—In the ophthalmia of new-born children, and also in the epidemic and the gonorrhœal forms of the disorder, solutions of nitrate are extremely valuable, though they often cause severe pain for a time. The lids should be separated and the eye cleansed by a stream of tepid water, and in acute, not very severe cases, a few drops of a solution (2 to 5 gr. in 1 oz.) should be instilled—in very severe cases with chemosis, a strength of 20 or 30 gr. in the ounce may be employed once or twice daily, but should be followed by a syringeful of plain water, or of weak salt-solution, in order to neutralize any excess of nitrate (*v.* p. 23). In chronic cases, especially when scrofulous in character, with thickened conjunctiva, photophobia, lachrymation, etc., the solid stick may be lightly used to the lids with advantage; but in all cases the liability to discoloration must be remembered, and the remedy not be used too often nor too long; when ulceration is present, or the membrane not entire, other remedies should be preferred.

Otorrhœa, with perforation of tympanum and with tendency to formation of polypus, is best treated by touching the tympanic mucosa with a concentrated solution of the nitrate: the discharge should be daily removed by ordinary antiseptic lotion.

Ozæna—Coryza.—In chronic nasal discharges, if the bones be not seriously affected, and in ordinary coryza, benefit may be derived from injections of nitrate of silver (2 to 5 gr. in 1 oz.). In the former condition, a cleansing and disinfectant nasal douche should first be used, and afterward the astringent should be injected from behind forward by means of a curved tube passed to the back of the fauces, and connected with a rubber ball.

Nitrate of silver in various forms is an important agent in the treatment of diseases of the *throat and air passages*, but its strong and caustic action is invoked much less frequently now than formerly; we require rather the astringent or alterative action to relieve congested, or brace relaxed parts. Dawosky concludes, after extensive experience, that, whenever local applications are required for congested mucous membranes, nitrate of silver gives the best results; besides its chemical influence, it stimulates the congested vessels to contract and get rid of their excess

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of blood. For congested conditions of the fauces with adherent secretion and patches of redness and swelling, he recommends a strength of 1 part in 8 (*Medical Record*, March, 1878), but I think it better to *begin* at least with half this proportion.

Tonsillitis.—In the early stage of this inflammation—it must be at least before suppuration has set in—a strong solution (30 to 60 gr. to 1 oz.) applied once in twenty-four hours will sometimes abort further progress. Judgment is required to determine the suitability of cases for this treatment, for if the inflammation be advanced and active, irritant applications tend to increase it. In sloughing ulceration about the fauces, strong nitrate solutions are sometimes serviceable, and are better than the solid caustic; but more active disinfectants, such as iodine or carbolic acid, are still better.

Diphtheria.—In diphtheritic inflammation with membranous deposit, I cannot recommend the strong nitrate; if the part be irritated it is more liable to inflame, and if the membrane be roughly detached the absorbents more readily receive morbid material, so that, although this remedy was at one time commended, I am satisfied that the use of a solvent or disinfectant spray is more serviceable, and is far more thoroughly and easily effected. Strong nitrate of silver is not a suitable local remedy for membranous croup (laryngeal diphtheria), or *acute* congestion of the larynx. I have seen almost fatal suffocative spasm of the vocal cords induced by the application of the solid nitrate in the latter condition. Guillon, however, states that the insufflation of finely powdered nitrate may be very useful (*Medical Record*, 1877); sometimes a weak spray (1 gr. to 1 oz.) has been of service.

Œdema Glottidis—Chronic Congestion.—This severe form of œdema is sometimes quite controlled by strong silver-solutions, which may obviate the necessity for scarification or more serious procedures. In *chronic* laryngeal and faucial congestion, a curved brush carrying a solution of 20 to 30 gr. to the ounce may be applied with the help of a mirror to the exact part affected, and with very good result. Dr. Horace Green and Dr. Hughes Bennett were early advocates of this method of treatment. Many surgeons, however, now prefer solutions of copper, zinc, or iron, as causing less irritation, and less risk of after-contraction, than the silver salt. A *weak* spray is of very little service in these conditions, and the use of the brush has largely superseded the method of insufflation which was approved by Trousseau. He used 3 gr. of the nitrate mixed in fine powder with 60 gr. of sugar of milk, and this was blown into the patient's mouth during a deep inspiration, by which some of it was carried into the larynx.

Laryngeal Phthisis.—The solution is, according to my own experience, of much service in the early stage of this disease, and has been recommended by the late Hughes Bennett, Marcet, and Sawyer, but ob-

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jected to by L. Thomas (*British Medical Journal*, i., 1878). It has been advised in malignant disease.

Relaxed Throat, etc.—It is, however, in chronic relaxed conditions of the fauces and pharynx, with dysphagia and constant discomfort, aching in the throat, cough, and hawking of phlegm, that the remedy gives most relief. There is no acute inflammation present, and the affected parts are either pale with prominent follicles, or swollen and of purplish color, with more or less viscid, yellowish secretion. In "clergyman's sore throat," the follicles of the pharynx mainly are affected, and in all these cases a solution of 20 gr. to the ounce, with glycerin, should be applied once daily, or on alternate days, while tannin, borax, etc., are used in the intervals.

In *aphonia* connected with local debility and relaxation, silver applications relieve by their astringent tonic action, and in hysterical aphonia the irritation excited is often sufficient to restore the voice.

Relief may also be given to obstinate *coughs* arising from relaxed faucial conditions, and not amenable to internal remedies, by a solution containing about 5 to 10 gr. in the ounce, applied once or twice daily.

Chronic Bronchitis.—In cases accompanied with profuse muco-purulent discharge, I have often proved the efficacy of a spray containing nitrate of silver. I use only weak solutions—from 1 to 4 gr. in the ounce—and find that they alter and restrain the secretion in a very satisfactory manner.

Erysipelas.—The power of the remedy in this disease depends much on the mode of its application; the mere drawing of a line of caustic round the inflamed margin (as sometimes practised) is illusory. The best method is that of Mr. Higginbottom, who advises previous cleansing of the part with soap and water, then with pure water, and afterward the thorough application of a saturated solution (20 gr. in each fluid drachm) two or three times over the whole affected surface, and beyond it on the healthy skin for about two inches. This is effective in the superficial forms of erysipelas, but not, according to my experience, when much œdema or cellulitis are present, and I am reluctant to advise it over an extensive surface, or in the idiopathic form. It causes severe burning pain, and in the latter condition, at least, does not always stay the inflammation, so that I prefer milder applications and appropriate internal medication.

Whitlow—Furuncle—Erythema.—These conditions are sometimes advantageously treated by the method of Higginbottom, but the solution may be made weaker, and nitrous ether employed as the vehicle: it does not dissolve so much as water, but 30 to 40 gr. in the ounce will be strong enough; this should be painted over the affected finger, or the commencing boil, or the inflamed and irritable patch. Chilblains are relieved by it, and it is said to prevent a threatened eruption of herpes if

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used early enough. To *bedsore*, in any stage, a solution of 5 to 10 gr. in the ounce may be applied with advantage.

Eczema.—The use of strong nitrate of silver in eczema should be reserved for chronic patches with much infiltration. Nitrous ether proves the best vehicle, because it dissolves sebaceous or fatty secretions, and allows the remedy to act better on the distended capillaries—30 to 40 gr. in the ounce may be used. Eczema in the neighborhood of ulceration yields to lotions of moderate strength. For eczematous or aphthous conditions affecting the genital organs, or the nipple, and commonly accompanied with severe itching and irritation, a solution containing 4 or 5 gr. in the ounce should be first used in cases that are somewhat acute; but, if relief be not given, a paint containing 30 to 40 gr. in the ounce should be carefully and lightly brushed over the part. Quite the best treatment for fissured nipples is to touch them thoroughly but lightly with a fine point of nitrate: all secretion should be cleansed from the part before such applications, and warm fomentations should be ready for use afterward, as the pain may be severe. In abrasions or aphthous conditions about the mouth, the solid nitrate is one of the best remedies, although a painful one.

Burns and Scalds.—In superficial burns the strong solution has been applied, and to deeper injuries, when the true skin is affected, the solid stick has been used with the object both of forming a covering from air, and of lessening the degree of cicatrization (Fricke). This method has not met with general support, but a modified plan was recommended by Mr. Skey, who used a lotion containing about 6 gr. in 1 oz. for infants, and twice that strength for adults, covering the part immediately afterward with cotton wool (*Lancet*, ii., 1861). A mixture with linseed oil has been commended (Wernher), and the solid stick is always useful in later stages when ulcerations are slow to heal. Hebra applies it once or twice daily, especially where there is liability to adhesions.

3. *Counter-irritant.*—The action of the remedy when applied locally in superficial inflammations, has earned for it the title of "caustique antiphlogistique," but we cannot recognize in it any distinctly caustic action, any more than we can verify the production of a "substitutive inflammation," which replaces for a time the original malady, and then itself subsides (*v.* p. 11). The main factor in the result is an astringent effect on the vessels and nutritive processes, but there are cases in which, when the nitrate is applied to some other than the affected part, it will relieve by an action which may properly be called counter-irritant or derivative, the "médication irritante transpositive" of Trousseau. Thus, Liston and Elliotson treated erysipelas by its application to the neighboring *sound* skin, and Lubanski, Egan, and others treated amenorrhœa by pencilling the os uteri (*Dublin Journal*, 1848).

Orchitis—Synovitis.—In these deeper-seated inflammations benefit

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may be obtained from strong nitrate of silver applied on this principle of counter-irritation. The best position for the application has been much discussed, some placing it as near the part as possible, others insisting that it shall be between the heart and the inflamed tissue, and others that it shall affect vessels which receive their supply from a different source than the affected part. The simple rule adopted by Mr. F. Jordan, with much success, is to apply the nitrate over the *adjacent vascular territory;* thus, in orchitis he acts upon the great vessels in the groin and front of the thigh (*Practitioner*, vol. ii.). In synovitis it is used round the affected joint, though iodine is usually preferred in this disorder.

In irritation of the *prostate gland or seminal ducts*, it may be applied to the perineum, rather than to the urethral membrane itself.

4. As a *Direct-irritant* (the "medication excitative" of Trousseau), the nitrate finds some applications.

Hydrocele.—The solid stick may be applied, for instance, to the interior of a hydrocele-sac after evacuating the contents, but an injection through a trocar is more under control: the object is to excite sufficient inflammation to induce adhesion (this is now better effected by iodine).

Tumors.—Small cystic or fatty tumors may be cured by inducing moderate suppuration, and one of the best means for this purpose is the injection into their substance of a few drops of solution containing 1 part of silver nitrate in 6 or 8 of water; this mode of treatment was specially introduced by Luton, who termed it "parenchymatous substitution."

Neuralgia—Sciatica.—Luton applied the deep injection of this salt also to the treatment of these maladies.

In sciatica of chronic and obstinate character, 10 to 20 drops of the solution injected deeply near the seat of pain will lead to a localized suppuration which sometimes quite cures the original malady: it is best used in the nates at the point of emergence of the sciatic nerve.

In other chronic obstinate neuralgia, and, according to Le Dentu, in any deep-seated neuralgic pain of any part, similar treatment has proved of service: of a solution containing 1 part of nitrate to 5 of water he injects deep into the cellular tissue 2 or 3 drops: this causes acute pain for the moment, and sometimes a small abscess afterward, but never serious trouble (*Medical Record*, 1877). Dureau, in a recent thesis (Paris, 1877), sums up very favorably the experience recorded up to the present time of this method of treatment; it is said to be both certain and rapid in its effects, and not to cause much irritation of the deep tissues. Luton himself used a 10 per cent., also a 5 per cent. solution, and others one of 25 per cent., injecting 5 min.—all with successful results.

In *Chronic Joint-Disease, Synovitis, etc.*, equally good results have been recorded from the method of Luton—*i.e.*, deep injections into the joint-cavity (*Medical Record*, November, December, 1877). The process

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may be compared with that of Thiersch for cancer, in which weak solutions only are used, and suppuration is not intended (*v.* p. 9).

THERAPEUTICAL ACTION (INTERNAL).—The value of silver compounds is acknowledged in certain disorders of the gastro-intestinal mucous membrane, and of the central nervous system. In the former their action is a local one, doubtless of the same character as that exerted upon the external surface; in the latter they are given for a "constitutional" effect of tonic or indirectly sedative character, which may perhaps be resolved into a regulating or astringent effect upon the capillaries (Hudson, Lane). In support of this view has been quoted the power also possessed by these salts of moderating uterine and other discharges, but this is perhaps only contingent on the improved state of the stomach-functions; in the present state of our knowledge, however, the record of clinical facts is of more importance to us than the theories formed to explain them.

Dyspepsia—Chronic Gastritis—Chronic Gastric Catarrh.—The nitrate and the oxide are both valuable in many of these cases, and in judging of their suitability in a given instance, it is not easy, nor is it essential, to draw a definite line between functional and organic disorder. Gastric pain, especially when severe, and coming on some time after food, with tenderness, distension, pyrosis, and vomiting, are sufficient indications. Dr. J. Johnson, one of the earliest observers of this use of the nitrate, found that mental depression, or motor disturbance of convulsive character, furnished additional indications for it ("On Indigestion," 1826). Dr. Symonds recommended it "in nervous irritability with passive or chronic congestion of the stomach." In Dr. Hudson's cases, pain of very acute character and long duration, with distension, thirst, constipation, and vomiting of sour fluid, were relieved within one or two weeks, but he gave the remedy (¼-gr. doses) with opium (¼ gr.), and hop (*Dublin Journal*, May, 1840). Dr. Osborne, a distinguished Dublin physician, found it valuable in gastralgia with "sour vomiting" (1831), and more recently we find Dr. Spender praising it as the "best remedy in pyrosis" (*Practitioner*, October, 1868), and Dr. H. Wood, "in vomiting of much yeasty fluid." I should attribute importance to its disinfecting properties in such cases. Dr. Wilson Fox also adds his testimony to the "well-established reputation of the silver salts in chronic gastric catarrh," and places them next to bismuth: he would generally prescribe them, however, with opium, while Frerichs, also a high authority, gave them with belladonna. The absence or the presence of constipation will be a useful guide to the choice of these adjuvants. In gastritis, Dr. A. Fleming obtained very good results from the nitrate, and his mode of using it would seem to obviate, if that be necessary, the objection urged by Brinton, and to some extent by Husemann, viz., that the smallness of the dose, and the dilution and chemical change of the drug, must make it almost inert. Dr. Fleming was accustomed to order ½ oz. only of distilled water containing from 1 to 4 gr.

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of the salt, to be taken fasting, and in the recumbent position, the patient then to turn himself from side to side, so as to insure contact of the remedy with different parts of the stomach-wall. In some cases he even injected the dose directly into the viscus, with a syringe and perforated tube (*Medical Times*, i., 1859). Dr. Hartshorn valued the nitrate in chronic gastritis; he gave it in pill (*American Journal*, July, 1849). My own use of the remedy has been generally in doses of $\frac{1}{20}$ to $\frac{1}{4}$ gr. every four or six hours in distilled water, and I have certainly observed from it much relief of discomfort and pain, flatulence, heartburn, and pyrosis, yet there is some uncertainty in its action (*v.* p. 24). Women suffering from the above symptoms, together with severe retching and vomiting of tenacious fluid, and a too frequent and profuse menstruation, are almost always relieved by it, but the maladies in question assume so many phases, and are more or less amenable to so many forms of treatment, that we cannot be surprised at difference of opinion as to the true value of this one.

It has naturally been thought that risk of caustic and irritant effects might be obviated, and equally good curative effects obtained by the use of the oxide of silver instead of the nitrate, and this was brought prominently before the profession by Mr. Lane (*Medico-Chirurgical Review*, July, 1840–41), and afterward, in a special treatise, by Sir James Eyre. The former records a number of cases with severe but intermittent gastrodynia, general uneasiness, nausea, and watery eructation, almost all relieved quickly by $\frac{1}{4}$ or $\frac{1}{2}$-gr. doses of the oxide: nothing is said about diet or other adjuvant treatment. Mr. Lane states further, that if organic mischief have resulted—if the tongue be tumid and cracked, and the pain constant, or the ejected fluid "glairy" (as in Todd's "follicular gastric dyspepsia"), then the remedy is of no service; but it is not necessary to adopt these limitations if other indications for the remedy exist.

Uterine Disorders.—Dr. Hudson and others remarked the great improvement in certain uterine symptoms during the exhibition of silver, and recorded cure of many cases of menorrhagia, of uterine leucorrhœa, and of painful menstruation, though not with the scientific precision now expected. Many cases occurred at the menopause, some during pregnancy, and in several a previous long sterility was followed by fecundation: simple vaginal leucorrhœa was not benefited.

Guided partly by this marked sympathy between the gastric and the uterine conditions, I have prescribed the oxide for nervous highly-sensitive women suffering from gastrodynia and pyrosis, with coincident uterine flux, and have often seen marked and immediate improvement in both symptoms, and without any drawback. The use of the medicine need not, however, be restricted to such cases; its action is somewhat similar to that of bismuth, and it may be used if that should fail to relieve. It has the advantage of being effective in a much smaller dose:

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$\frac{1}{10}$ to $\frac{1}{2}$ gr. is usually quite sufficient, and in the form of a minute pill this is readily taken. I have not seen the irritation from it which has sometimes been described, nor the salivation which might be produced by its too prolonged use, nor any symptoms of argyria. It should not, however, be continued for many weeks consecutively. It is useful for cases in which arsenic also relieves, and an interesting fact is that this remedy and bismuth have often an equally good influence over uterine loss when connected or coincident with gastric disorder.

In the *cardialgia and vomiting of pregnancy* I have found it useful when many other remedies fail to give the slightest relief.

Gastric Ulcer.—In so serious an organic disease, which must, of necessity, often end fatally, it is not surprising if the powers of the silver compounds have been called in question. Cases of marked relief, if not cure, by these remedies have, however, been recorded (Stillé), and it seems reasonable to allow that if they can relieve ordinary gastritis, they may relieve the same condition when dependent on a local lesion; they lessen local congestion and local nerve-irritation, and in some cases, at least, they form a protective layer of albuminate, and probably thus relieve the pain of gastric ulcer.

Jaundice.—Dr. Peebles (U.S.) has recorded several cases of jaundice in which rapid improvement followed the use of nitrate of silver given in $\frac{1}{4}$-gr. doses twice daily for two to ten days: he attributes its good effects to its modifying the state of the mucous membrane, and relieving a chronic gastro-enteritis, and lessening the obstruction of gall-ducts by diminishing glairy mucus (*American Quarterly Journal*, July, 1849).

In *catarrhal jaundice*, with pain and functional stomach-disorder, Dr. Bartholow reports good results from similar treatment, which he compares to that by mercury or arsenic.

Chronic Diarrhœa—Dysentery.—I have obtained great benefit from nitrate and oxide of silver in many forms of these disorders—in serous diarrhœa, in chronic and periodic forms, in diarrhœa after fever, and in that of dysenteric character.

Graves preferred the nitrate (which he gave in grain doses) to any other astringent or to opium, but (as remarked by Stillé) he avoided it in cases of ulceration, when really its advantages may best be proved. Dr. J. MacGregor reports several cases of exhausting diarrhœa during advanced phthisis, in which the relief was marked and immediate; he gave the remedy also in 1-gr. doses with $\frac{1}{4}$ gr. of opium, and in enema (*British and Foreign Review*, September, 1841). I have myself often found it of the greatest advantage in such cases, restraining the profuse discharge, and aiding to strengthen the patient; I have given from $\frac{1}{10}$ to 1 gr. In the form of enema, containing 3 to 4 gr. in 2 oz. of distilled water, it is a valuable remedy for chronic dysentery and ulcerative conditions of the rectum; the enema may be repeated every six to twelve

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hours for three or four times, if necessary. If ulceration or congestion be situated higher up in the intestine, the nitrate is best given by the mouth in pill, since it is thus most likely to reach the affected part unaltered, and to exert the local action which is desired. The chloride of silver has also been used with advantage in chronic dysentery.

Diarrhœa of Children.—The nitrate has been recommended by Trousseau, Mauthner, etc. I do not think it advisable for acute cases, for it is uncertain in action, but, in prolonged and obstinate cases, a few doses often act well; they may be given by the mouth or rectum.

Typhoid Fever.—Dr. Pepper has recorded fifty cases of typhoid fever in which, after the second week, the medicinal treatment was nitrate of silver (¼ gr.), with small quantities of belladonna and opium; only one case was fatal, and he considers that these remedies act favorably by limiting follicular catarrh and modifying its secondary effects (*Boston Journal*, October, 1877).

Diseases of the Nervous System.—It is curious that silver was early appropriated to the treatment of cerebral disorders by the theories of astrology, which associated both the metal and the malady with the influence of the moon: by the time of Linnæus its medicinal virtues were so far distrusted that he describes only its "power as political, its use, commercial." It retained, however, some reputation in epilepsy, and of late years there has been further evidence of a neuro-tonic power exerted by it rather upon the spinal than the cerebral nervous system, as illustrated in some forms of paralysis.

Epilepsy.—Unless we are wholly to reject past records and the opinion of distinguished physicians, the nitrate has given good results in a large number of epileptic cases. Heim considered it the best of remedies, and Trousseau, who used also the chloride, places the silver salts second only to belladonna ("Traité," Ed., 1868). We need not, however, quote many authorities to the same effect: we recognize that it has relieved, sometimes even seemed to cure, cases of this disease, and may, therefore, under certain conditions, relieve others. We should not, with Krahmer, consider it most suited for the robust, with symptoms of head congestion, but rather for the delicate with morbidly irritable and susceptible nerve-system, and a languid state of the organic functions (Stillé); it is in the pallid and anæmic that strychnia acts well sometimes (Tyrrell), and it is in similar cases that I should be hopeful of good results from silver. Curci considers that it does good in epilepsy connected with spinal disease, but when dependent on local lesion—as hemorrhage, softening, or tumor—the malady is not influenced by it. More definite indications we cannot at present lay down, and must acknowledge that, of any given number of cases, the majority at least will not yield to this remedy, and others, if they receive temporary benefit in the prolonging of the interval or lessened severity of the attacks, will ultimately relapse.

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The greatest objection to nitrate of silver, and one which has led to its comparative disuse, is the possibility of its discoloring the patient, and this even without curing his malady—I have seen epileptics discolored by the medicine, and yet suffering as severely as ever from their convulsions. Unfortunately the nature of the disease requires a long continuance of treatment, and therefore a medicine must be preferred which shall, at least, not inflict so visible an injury, and we need seldom prescribe the silver salt until a fair trial has been made of bromides, of belladonna, etc. If, however, it be decided upon, then a purgative should be given at the commencement of, and occasionally during treatment; the remedy should be omitted for a few days at intervals, and the gums should be carefully watched for signs of systemic saturation. The use of nitrate for *epilepsy in children* has been objected to by Lœbenstein, but I have seen it of service in chronic cases. Brenner recommends the chloride in infantile convulsions, and also in the brain-affections of typhus. Niemann found advantage from the ammonio-chloride in epilepsy and melancholia.

Paralysis—Ataxia.—We cannot speak with any confidence of the power of silver compounds to relieve serious or chronic cases of this kind, though there are not wanting records of improvement, more or less marked, obtained under their use. Wunderlich reported seven cases of ataxy arrested in progress under 5-gr. doses, two or three times daily; while Charcot and Vulpian related five cases that had lasted respectively two, four, five, and two of them fifteen years. A pill containing $\frac{1}{6}$ to $\frac{3}{4}$ gr. of nitrate was given daily for from thirty-five to sixty days, and in every case, in the course of a week, improvement commenced as to sensibility, power of placing the limbs, as to sight, and especially as to lessening of pain ("Mémoire sur le Nitrate," *Bulletin de Thérapeutique*, 1862). The report of such cases caused much sensation, but Topinard, who criticises them closely, asserts that in some the diagnosis was imperfect, and that admitting it in the others to be correct, there were unsuccessful cases to be compared with them, and many others unrecorded ("De l'Ataxie Locomotrice," Paris, 1864). He has collected altogether twenty-eight cases, more or less favorable to the efficacy of the nitrate, and nine unfavorable; to these, he has added seventeen cases carefully noted under his own observation: commencing with $\frac{1}{12}$ gr. daily, he continued it for ninety days, interrupting the course every eight days for a week; then $\frac{1}{6}$ gr. was given for four months. In the first case reported, no good result was obtained, though erections recurred; at the end of the treatment the patient was worse, and the same has to be said of eleven other cases: in the remaining five there was some amelioration of symptoms. Althaus, on the other hand, has had, on the whole, a favorable experience with this remedy, and I believe that I have seen benefit from it in relieving the "lightning pains," and in arresting, for some time at least,

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disorder that was progressing, but it is no specific against locomotor ataxy.

Diphtheritic and Mercurial Palsy.—A case of the former kind, cured under the use of nitrate, is recorded (*American Journal Medical Science*, April, 1865, p. 485), but I am not aware of others. Fairly rapid recovery in six instances of mercurial palsy is reported by Sementini with doses of from ⅛ to 3 gr. daily (quoted by Dr. Waring).

Nerve-Debility—Headache.—In some few cases of nerve-debility and depression connected with overwork, anxiety, or excess, and exhibiting hypochondriacal symptoms—morbid fear, impaired mental capacity, and frequent rather deep-seated fixed headache—I have seen improvement under the use of nitrate, and have felt justified in connecting it with this drug, because iron, and bromides, and other remedies had been used without advantage, and the patient's mode of life and circumstances were not altered when the silver was commenced.

In *hysterical* or *nervous* headache it was valued by Dr. Graves, and others have found it useful in neuralgia, for which Paterson recommends especially the iodide. If the headache be accompanied with constipation or gastric disorder, an occasional laxative is required.

Various Diseases.—Other disorders, which may either be called "nervous" in character, or are connected at least with reflex nerve-disorder, and which the salts of silver have been found sometimes to relieve, are such as *chorea*, *angina pectoris* (Copland, Dict.), *spasmodic asthma* (Waring, Curci), *palpitation* (Kopp), *vertigo* (Rademacher), *pertussis* (Berger): for this last iodide is especially recommended. They have been given also in more general diseases, as *intermittents* (Sokolow), *diabetes*, and *phthisis* (Brady, Moore), the object desired in these latter cases being mainly to lessen the excessive discharges from the kidneys, the skin, and the bowels; in some instances they have certainly succeeded, though we could not expect them to alter the ultimate termination of such maladies. In *dropsy* the nitrate was given by Boerhaave as a purgative in 2-gr. doses, and has been more lately commended by Dreyer (Husemann). In *syphilis* the chloride and oxide were given by Serres and others, but their value has been disproved by Ricord. The ammonio-chloride has been used as a cathartic and a vermifuge.

Preparations and Dose.—*Argenti nitras:* dose, ⅛ to ¼ gr. (B.P.); it may vary from $\frac{1}{10}$ to ½ gr., and more has been sometimes prescribed. *Argenti oxidum:* dose, ½ to 2 gr. in the form of pill.

The dose of the *chloride* is about the same as that of the oxide, though upward of 30 gr. have been given without gastric pain (Trousseau): the dose of *iodide* and other salts is also about the same as the oxide.

As a caustic the solid nitrate may be used alone, or "mitigated"—*e.g.*, with nitrate of potash (Crayons de Barral, de Desmarres), or with

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sulphate also (Guyot). In default of a metal, or caoutchouc, or quill holder, melted sealing-wax forms a convenient coating, and a file, or friction with wet lint, sharpens the point better than a knife: for small fistula or numerous leech-bites, a silver probe, dipped as required in the melted salt, is very convenient. The finely powdered nitrate, diluted (as with sugar), has been used for the throat and larynx, and abroad, charpie, dipped in a strong solution and dried, is used as a dressing for indolent wounds, and known as the black or caustic charpie of Riboli (Husemann).

Of solutions, 40 gr. in the ounce will prove caustic to mucous membranes, and from 80 gr. upward caustic to the skin; distilled water, glycerin, or nitrous ether may be used as solvents (*v.* p. 14); opium may be added to diminish pain, and after a strong application the part, especially if it be the eye, should be bathed with warm salt water to neutralize any excess of caustic—20 gr. to the ounce is a useful strength for an astringent solution, but a proportion of 10, 5, and even 1 gr. to the ounce is suitable according to the condition of the affected part, and may be used in lotion, injection, or collyrium, as already described, it being remembered that the weaker solutions require to be used the more frequently: the disadvantage of the salt staining linen must be borne in mind.

Both the nitrate and oxide have been used in stimulating and astringent ointments: thus, in the Hamburg Pharm., 15 gr. are ordered with 1 dr. of Peruvian balsam and ½ oz. of zinc ointment (Ungt. Nigrum), and Lane used the oxide in specific and other ulceration, but I do not think ointments a good form of the remedy.

Since the salts of silver are readily decomposed, they should be mixed as little as possible with organic or mineral substances, and haloids, sulphides, alkalies, soaps, tannin, and astringent extracts should be excluded from prescriptions for silver compounds: it is important to mention, also, the exclusion of creosote, for explosions have occurred from its trituration with oxide of silver and organic substances. Solutions of the nitrate for internal use should be kept as much as possible from air and light, and are therefore commonly ordered in covered or dark-glass bottles: they may be made with distilled water or with glycerin, and sometimes a few drops of nitric acid are added to prevent reduction; syrup may be given with it for children. Delioux prescribed it with an equal part of salt in a weak, sweet, albuminous solution (white of egg), and Deniau added to this a small proportion of bromide of potassium to redissolve the precipitate; but, in such combinations, the object of which is to secure solubility and absorption, we are not giving the nitrate, but a complex chloro-albuminate. Discoloration of the lips and teeth, and nauseous taste, are, however, drawbacks to the use of any solutions. A pill may be made with crumb of bread according to an old and well-known formula (Boudin): the decomposition into chloride that may occur is unimportant (*v.*

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p. 2). Argilla and silica and chocolate have been recommended as vehicles.

The oxide is always given in pill or confection, and this form is to be preferred for "constitutional" effects, or for an action on the lower parts of the intestinal tract. It is usual to direct a patient taking these medicines to abstain from much salted food before or after the dose, as likely to hinder absorption into the blood.

[PREPARATIONS, U. S. P.—*Argenti cyanidum*, used in preparing hydrocyanic acid; *Argenti nitras; Argenti nitras fusa; Argenti oxidum.*]

ARSENICUM—ARSENIC, As,=75.

The name arsenic is applied by common usage both to the element and to its *oxide*, which is more correctly termed arsenious anhydride; it it also called white arsenic, or arsenious acid.

The element, formerly classed with metals, now with metalloids, occurs sometimes native, but generally in alloy with iron, copper, and other metals, as oxide and sulphide. Nearly all sulphur contains some arsenic, and from these different compounds it is liable to pass undesignedly into many pharmaceutical preparations. Mineral waters also frequently contain it; Tripier has noted its almost constant occurrence in chalybeate, and Thénard in saline springs, though in minute proportion: those of Plombières contain but 0.0008 gr., Vichy 0.01 gr., and La Bourboule (the largest amount) $\frac{1}{10}$ gr. in 16 oz.

CHARACTERS.—The metalloid is a steel-gray solid of metallic brilliancy, readily oxidizing and tarnishing on exposure to air. It volatilizes at a dull heat, the colorless vapor having a garlic-like odor. It burns when heated in the air.

ACIDUM ARSENIOSUM—ARSENIOUS ACID, OR ARSENIOUS ANHYDRIDE—WHITE ARSENIC, As_2O_3,=198.

PREPARATION AND CHARACTERS.—Arsenious acid is prepared by sublimation from arsenical ores, and condenses in the *cooler* parts of the retort as a heavy powder, fine and white, like flour; in the *hotter* parts, it forms a vitreous mass, transparent and amorphous, which becomes, on exposure to air, opaque and crystalline, and is usually seen in smooth milk-white or yellowish pieces not unlike porcelain, and stratified in appearance according to the different opacity of its layers; the change from the amorphous to the crystalline form is accompanied with phosphorescence (one of several of its analogies with phosphorus). The two forms

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differ in density and in solubility, the transparent acid dissolving in about 100, the opaque in about 80 parts of water at 15° C.

The powder is not readily wetted by water, so that it is apt to remain floating on the surface, or adherent to the sides of a vessel. Organic products, milk or mucus, render it *less*, acids and alkalies *more*, soluble; oils and alcohol also dissolve it. It crystallizes from a saturated solution, or after slow sublimation in minute shining octahedra, or in rhombic prisms (like oxide of antimony, with which it is isomorphous): sprinkled on a red-hot surface, it evolves scarcely visible vapors of metallic arsenic, which have an odor like garlic, and, at a few inches from the hot surface, change to dense white odorless smoke, being the acid re-formed by oxidation. Arsenious acid itself has no smell: its taste is sharp and rather nauseating (Hirtz), but, in such small quantities as may be taken for trial, nothing more than a slight sweetness and grittiness will be detected (Christison).

LIQUOR ARSENICALIS—ARSENICAL SOLUTION—FOWLER'S SOLUTION.

PREPARATION.—By boiling together arsenious acid and carbonate of potash, and adding to the solution (when cold) tincture of lavender, and sufficient water to preserve a proportion of 4 gr. in the ounce.

CHARACTERS.—A reddish, alkaline liquid, with the odor of lavender: it contains a mixture of arsenite and carbonate of potash.

LIQUOR ARSENICI HYDROCHLORICUS—HYDROCHLORIC SOLUTION OF ARSENIC.

PREPARATION.—By boiling arsenious acid with hydrochloric acid and distilled water, preserving a proportion of 4 gr. to 1 oz. (This solution corresponds in strength with liquor arsenicalis; it is nearly three times the strength of liquor arsenici chloridi, London, and of the original acid solution of De Valangin.)

CHARACTERS.—A colorless liquid of acid reaction and sp. gr. 1.009.

SODÆ ARSENIAS—ARSENIATE OF SODA.

PREPARATION.—By heating together arsenious acid, nitrate and carbonate of soda, dissolving and crystallizing.

The *liquor sodæ arseniatis* contains 4 gr. of the anhydrous salt in 1 oz. of distilled water.

CHARACTERS.—The salt occurs in colorless transparent prisms soluble in water and alkaline in reaction: the *solution* is also colorless and alkaline.

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Arsenic Acid, As_2O_5, the higher oxide of arsenic, is also white and solid, but is so soluble as to be almost deliquescent, and it has a strong acid reaction. It is not employed in medicine in its free state, but in combination with soda and iron. In the arts it is largely used in the printing of cotton stuffs, and in the manufacture of aniline dyes.

Ferri Arsenias—Arseniate of Iron, $Fe_2As_2O_8$ (*v.* p. 134).

Liquor Arsenici et Hydrargyri Hydriodatis.—A solution (not officinal) containing a double iodide of arsenic and mercury, has long been in use under the name of its proposer—Mr. Donovan, of Dublin (1839). It is a pale-greenish colored liquid, having no odor, but a styptic taste; it probably contains the red iodide of mercury and ter-iodide of arsenic. In each fluid drachm there is about $\frac{1}{15}$ gr. arsenic, $\frac{1}{4}$ gr. mercury, $\frac{3}{4}$ gr. iodine.

Tests.—1. Sulphuretted hydrogen gives a bright yellow precipitate of arsenious sulphide (As_2S_3) in acid solutions of arsenious acid or the arsenites.

2. *Hume's Test.*—Ammonio-nitrate of silver gives a lemon-yellow precipitate of arsenite of silver (Ag_3AsO_3) in solution of arsenious acid, or the arsenites. The same silver-salt gives a similar reaction with phosphoric acid, but with arsenic acid and the arseniates, a chocolate-colored precipitate of arseniate of silver (Ag_3AsO_4).

3. Ammonio-sulphate of copper gives with compounds either of arsenious or arsenic acid a light-green precipitate of arsenite of copper ($CuHAsO_3$), Scheele's green.

4. *Marsh's Test.*—Generate hydrogen by the action of a hot solution of caustic potash or soda on zinc ($Zn+2KHO=K_2ZnO_2+H_2$). Fleitmann has shown that antimony will not combine with this form of hydrogen, but that arsenic will. Place the solution to be tested in a "Marsh's apparatus," and if arsenic be present it will combine with the nascent hydrogen to form arseniuretted hydrogen ($As_2O_3+6H_2=3H_2O+2AsH_3$). On igniting the jet of gas (which burns with a bluish flame), and depressing upon it a cold porcelain plate, an arsenical stain will be deposited, while the hydrogen is burned off into water. The stain has the following characters:—(*a*) metallic brilliancy; (*b*) hair-brown color; (*c*) volatility; (*d*) solubility in chloride of lime; (*e*) non-solubility in cold disulphide of ammonium; (*f*) when evaporated with a drop of nitro-hydrochloric acid it yields a residue of arsenic acid, which gives a brickdust-red turbidity on the addition of nitrate of silver.

5. *Reinsch's Test.*—A piece of copper foil, when boiled in an acid solution of an arsenical compound, will become slate-gray from the deposition of a fine film of metallic arsenic. This test, to be complete, must be verified by heating the coated copper in a narrow glass tube, when metallic arsenic will sublime, and be deposited in a ring on the cooler part.

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For the "reduction test" of white arsenic, it should be placed with "black flux" in a similar tube perfectly dry, and, on heating first the charcoal and then the arsenic, the latter sublimes and is deposited in a metallic ring as above mentioned.

ABSORPTION AND ELIMINATION.—Since the observations of Schmidt, Mialhe, and others, *metallic* arsenic has been considered inert. Recently, however, Schroff has shown that it may exert a strongly poisonous action, and that doses of 8 to 15 gr. have caused gangrene of the stomach and death in thirty to forty hours (*Zeitschrift der Arzte*, i., 1858). It is probably oxidized before absorption.

Arsenious acid in all its combinations, and by whatever channel introduced—by mouth or by rectum, by the lungs or by the skin—is readily absorbed, and has been detected in the blood a few minutes after its administration. It passes out by the skin and mucous membranes, by the various glands, as the salivary and even the lachrymal, but mainly by the kidneys.

The rapidity of elimination varies; in some cases, none of the substance could be detected in the secretions three days after the last dose, but in Ludwig's observations on animals, if small quantities were given for a fortnight and then omitted, the urine was not quite free till three weeks afterward (*Medical Record*, 1877). Gubler gives six weeks as the time during which it may continue to pass out, and when it has ceased to do so it may reappear after administration of iodide of potassium; hence it seems probable that elimination is not always complete, and that of what is taken, a part may be deposited in the tissues and occasion so-called "cumulative" effects. Recently, arsenic has been found to be specially deposited in the *nervous* system; thus, if in fresh muscle 1 part is found, the proportion in liver is 10.8, in brain 36.5, and in spinal cord 37.3 (Scolosuboff: *Annales d'Hygiène*, January, 1876). This became a matter of great importance in a recent French trial (Danval), when the experts were blamed for not examining the brain and cord (*British Medical Journal*, ii., 1878, p. 73); these parts should henceforth be analyzed as carefully as the abdominal viscera. Caillol (de Poncy) offers some analyses to show that arsenic partly displaces phosphorus in nerve-compounds (*Medical Record*, 1878). If any be contained in the body at death, it may be detected after an almost indefinite period.

PHYSIOLOGICAL ACTION (EXTERNAL).—Preparations containing arsenic produce local irritation, inflammation, or destruction of tissue, in varying degree, according to the strength and character of the application. Dry white arsenic in mass may not injure the unbroken skin, but arsenical powders are apt to produce eruptions of various kinds on exposed surfaces, and especially irritative effects on the pudenda, in those who are employed in the manufacture of green dresses, wall papers, artificial flowers, etc. (*Annales d'Hygiène;* Dr. Guy: *British Medical Journal*,

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ii., 1863, etc.). Perforation of the septum nasi has been noted, and anal ulceration has followed the local use of a green paper colored with arsenite of copper. Arsenic dissolved or moistened is still more irritating, and those who use it, for instance, in sheep-washing, generally suffer from eczema of the scrotum, etc. (*Lancet*, 1857). Those who work with arsenical powders are liable also to various degrees of acute and chronic arsenical poisoning; and green colors are not the only dangerous ones: fuchsine, a *red* dye, contains much arsenic (Ludwig: *Medical Record*, 1877), and *blue* gloves have shown arsenic on analysis (*British Medical Journal*, ii., 1878). The use of green-colored cards has caused a disease of the nails resembling psoriasis, and green hat-lining has caused eczema (Farquharson: *British Medical Journal*, ii., 1879). The external use of a violet powder adulterated with arsenic proved fatal to thirteen children out of twenty-nine subjected to it (*British Medical Journal*, ii., 1878).

The continued application of a strong arsenical compound has a caustic, destructive effect, which is not simply a *chemical* one, like that of caustic acids or alkalies, and is not exerted on the dead subject (Hirtz), but is produced by interference with nutritive processes in the part, causing rather a condensation and "mummifying" of tissue than an actual destruction (Gubler). It is much more active in unhealthy, ill-nourished tissue (*e.g.*, that of lupus), than it is in normal tissues. Very strong arsenical applications produce much local inflammation, and so far interfere with the action of absorbents that the effect remains local only; but unless in such strong concentrated form, arsenic is readily absorbed, especially from wounds and mucous surfaces; hence its surgical use has led to serious constitutional symptoms, and even to death. Roux describes the application of an arsenical ointment—1 part in 32—over a space of 1½ square inches of a cancerous breast for one night only, and death from poisoning on the second day. Sir Astley Cooper relates a fatal case from the use of an arsenical solution to a "fungus of the eye" (*Lancet*, i., 1837).

Arsenical paste applied to an inflamed tooth-pulp has also proved fatal, and Graham has recorded vomiting, severe pain, convulsion, and death from the use of a plaster containing half its weight of arsenic to a cancerous breast (*Glasgow Medical Journal*, 1869); the prescriber of the plaster was tried for homicide, and many similar cases have been before the law courts.

The *antiseptic* power of arsenic deserves mention: it is largely utilized in the dissecting room, and seems to have retarded the process of post-mortem decay in some cases of poisoning when large amounts have been used. The recent researches of Johannsohn assign it, however, but a limited power: he found that small quantities checked fermentation in yeast and syrup, but only for a time: in lactic fermentation it diminished

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the growth of one fungus, but favored another. The same thing occurred in urine: it exerted no influence on non-organized ferments, such as pepsin, amygdalin, etc. (*Archiv für Exper. Path.*, Bd. ii., p. 106).

PHYSIOLOGICAL ACTION (INTERNAL).—The blood and the nutrition-processes are altered by arsenious acid and its compounds, but the symptoms of its physiological action are mainly evidenced in the *alimentary canal*, the *mucous membranes*, and the *nervous system*, and in different cases these parts are affected in different degree, according to the dose, the time and mode of its administration, and the constitution of the individual.

Digestive System.—Very small doses, such as $\frac{1}{30}$ to $\frac{1}{15}$ gr., may be taken for some time without other effects than such as are of stimulant and tonic character—*e.g.*, improvement of appetite, sense of warmth at the stomach, and general invigoration; but usually, sooner or later, these symptoms are replaced by those of irritation and malaise. Trousseau quotes from Kœpl the case of a servant who, desiring to get rid of a severe mistress, mixed with her food for some time very small doses of arsenic: the mistress, however, improved in appearance and in stoutness, and the plot was only detected after the use of a large poisonous dose. Doses of $\frac{1}{10}$ to $\frac{1}{3}$ gr. are liable to produce soreness of mouth, with some salivation and dysphagia, fœtid or sour taste, thirst, heat and constriction in pharynx, with nausea or vomiting, gastric pain, flatulence amounting to tympanitis, and diarrhœa. Vaudrey found copious pultaceous stools follow the medicinal use of arsenic without toxic symptoms. One of the early symptoms of the physiological action of the drug is a slimy silvery aspect of tongue, "as if nitrate of silver had been lightly applied" (Begbie), an appearance produced by a thin coating of mucus secreted under the influence of irritation. After continued doses, the tongue becomes red or brown, cracked and tremulous, the gums bleed, and the buccal membrane becomes covered with aphthous or even membranous patches like a true diphtheritic condition (*British Medical Journal*, i., 1862). Vomiting becomes so frequent that all food is rejected, and emaciation sets in rapidly, an effect which has been termed "tabes arsenicalis."

After poisonous doses, which may be stated at 2 gr. and upward, the symptoms already described become intensified; pain especially of most severe burning, cramping, spasmodic character comes on within half to one hour, in the region of the stomach and navel, spreading thence over the whole abdomen, which becomes contracted and hard: the ejecta are offensive, and yellowish or greenish in color, not unlike bile (unless, as often occurs in cases of poisoning, soot or indigo has been mixed with the arsenic); hiccough attends the vomiting and purging; the latter becomes involuntary, and is accompanied with severe tenesmus, and the general symptoms may closely simulate those of cholera (*Lancet*, ii., 1870).

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On the other hand, in some exceptional cases, the vomiting has been only moderate, and there has been complaint of coldness rather than heat; in others, there has been almost entire absence of pain, the patient remaining in a dull and semi-narcotized condition, and in several even severe cases, a remission of symptoms has occurred for some days before death (cf. Taylor: *Guy's Reports*, 1850).

In experimenting with frogs, Dr. A. Lesser found that intestinal peristalsis was increased by arsenic, and local tetanic contractions occurred from immediate irritation of ganglia in the intestinal coat (not indirectly from influence of the central nervous system): gastro-enteritis was also produced by the drug, but he did not, as Böhm did, find it more poisonous when given by the mouth than by a vein. It was eliminated by the intestinal mucous membrane (Virchow's *Archiv*, 1878; *Lancet*, ii.), and we may add here that by whatever channel toxic doses of the drug are given to men or animals, gastric inflammation is commonly determined.

Nervous System.—The early effects of very small doses are usually tonic in character, there being a general sense of improved power. The same fact was noted when describing effects on the digestive system, and it is possibly not a primary nerve-tonic effect, but rather dependent on improvement in appetite and assimilation of food.

Full medicinal doses, long-continued, give rise to numbness and pricking sensations with tremor or stiffness of limbs.

Irritant doses cause gastric pain, as already described; sometimes *headache* has been a marked symptom, as, for instance, in a large number of children who each received about 1 gr. of white arsenic in milk ("Taylor on Poisons," p. 295), and in many persons poisoned by the accidental admixture of a small quantity of arsenic in bread: they suffered also from a feeling of constriction over the forehead, vertigo, and tinnitus (Dr. Feltz: *Lancet*, i., 1880), from visual sensations of light or flame, prostration, and feebleness of lower extremities, and in these, as well as in other cases, pain in the back has been urgent (*British Medical Journal*, i., 1873). Sometimes the extremities have been very sensitive. Restlessness, insomnia, grinding of teeth, giddiness, irritability, and depression are frequent symptoms.

The effects of *poisonous* doses (6 to 8 gr.) are often ushered in with rigor, profound depression, and extreme anxiety. Restless tossing of arms is commonly noted, and later, numbness, cramps, and twitchings of all muscles. The œsophageal spasms may simulate those of hydrophobia, and the muscular cramps may amount to opisthotonos—convulsions alternate with delirium, the special senses become impaired or lost, the mental faculties torpid (the stupor may suggest narcotic poisoning), and syncope or collapse may close the scene. There may be local palsies, as of limbs and sphincters in the course of arsenical poisoning, and, as the effect of

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the drug in this direction is not so generally known, we may, with advantage, speak of it more fully.

Arsenic exerts a paralyzing influence certainly upon sensory and motor, and we may say *probably* upon vaso-motor nerves also. Dr. Sklarek, experimenting on the frog, found that arsenical injections, in minute quantities, destroyed common sensibility, probably by influence on the cord (Reichert's *Archiv*, 1866). Lesser, while verifying this, noted a transient increase in reflex irritability, then diminution of it, then cessation; after some time the frog became completely paralyzed.

Drs. Ringer and Murrell, remarking that paralysis occurs in the same order after *mechanical arrest of circulation* (as by ligature or excision of heart), instituted experiments to show whether the latter was the real factor in Sklarek's results, and concluded that they were due rather to a toxic action on the central nervous system; peripheral motor nerves retained their function for some time, for the muscles continued to contract under direct galvanic stimulus; ultimately both nerves and muscles were paralyzed by arsenic, and they ceased to re-act long before similar muscles did in a *brainless* frog, and the observers named concluded that "arsenious acid is a protoplasmic poison, affecting first the more highly organized nervous centres, next the nerves, and last the muscles: . . . that it is a poison to all nitrogenous tissues (*Journal of Physiology*, i., 1878–79, pp. 227, 228).

Clinical records clearly indicate *paralysis* as a symptom of arsenical action. So early as 1711 Morgagni notes "tremor of limbs, and palsy of feet" (Op., vol. iii., Trans. Alexander, Letter 59). Mr. Trend reports the case of a pregnant girl, who took 2 gr. twice daily for three months, and besides intestinal symptoms, suffered from pricking pain in both legs, impaired sensation, and loss of power (*British Medical Journal*, ii., 1858). Partial paralysis and numbness from habitual taking of the drug are recorded in Schmidt (Bd. clxv., p. 238), and tremor and partial palsy from exposure to arsenical vapor in aniline works, by Dr. G. de Mussy (*Lancet*, i., 1876). Dr. Leroy (d'Etiolles), who has written specially on the subject, describes a case of paraplegia succeeding to acute arsenical symptoms after the application of a caustic paste to a cancerous breast, and another aggravated case of paraplegia, weakness and anæsthesia of arms with diarrhœa, and ultimately death from marasmus (*Gazette Hebdom.*, 1857).

Christison has remarked that arsenical palsy resembles that of lead in its character, and Gubler and Duchenne have found it sometimes indentical. Leroy, however, points out that it not so invariably affects the *extensors*, and that it is more generalized.

The *wasting* of limbs is more general, and they may become semiflexed; when all are affected, the upper recover before the lower,—a point of difference from cerebral palsies. An average duration is from four to ten months, and the prognosis is favorable under treatment.

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Circulatory System.—After administration of arsenic, analysis has detected it in the clot—*i.e.*, united with globules, and not simply dissolved in the serum. Claude Bernard taught that it acted on the corpuscles in such manner as to diminish the activity of interchange of oxygen and carbonic acid (*Medical Times*, ii., 1861). The experiments of Brodie had already indicated *undue fluidity* of blood as an effect of arsenic, and modern observations refer this condition to a solvent action on hæmoglobin: thus, if arseniuretted hydrogen be passed into defibrinated blood, it becomes black, and gives with the spectroscope one large dark band instead of the two normal ones; by degrees, the spectrum wholly disappears, the hæmoglobin is destroyed, and the liquid turns yellowish-green. It seems probable that the same gas is developed to some extent from arseniates absorbed into the living organism, and that it exerts a similar destructive action on the globules; this would explain the anæmia, and the consequent œdema and anasarca, met with after continued use of even medicinal doses, as well as the icteric tint of skin, and the petechiæ and hemorrhages in cases of poisoning. Though there is evidence that in certain forms of anæmia the number of the corpuscles is increased under arsenic (Gowers: *Practitioner*, July, 1878, and Bramwell), there can be no doubt, that an opposite result follows both its long-continued use in disease, and any appreciable quantity of it taken by healthy persons. Thus, Lemare-Piquot (Honfleur), suffering from cerebral congestion, had himself bled many times, and by careful observations of the proportion of clot to serum showed that the continued use of arsenic could markedly lessen the former. The normal maximnm proportion of clot he reckoned at 54 per cent.; with any amount above this, cerebral symptoms, such as giddiness and oppression, appeared. In October, 1845, when suffering from such a condition, he found, on being bled, that the proportion of clot was 68 per cent., the serum being at 32 per cent. only. During the next four years he was bled more than twenty times with but partial and temporary relief. In March, 1849, he began the use of arsenical solution in small doses twice daily, at that time his proportion of clot being 69 per cent. After one month's arsenical treatment he felt well, and the proportion found on bleeding was reduced to 52 per cent. In succeeding years the same result occurred several times; he illustrated it also in other cases, and concluded, both from analyses and clinical results, that arsenic always rendered the blood less plastic, and lessened the number of globules (*Bulletin de Thérapeutique*, t. lvii., 1859). More recently Cutler and Bradford also found red and white corpuscles to be diminished in number under arsenical medication, and Malcolm Morris reports diminution in some cases of psoriasis when the general health was good—*e.g.*, F., aged twenty-three, on August 14th, showed 58 corpuscles in each square (of Dr. Gowers' instrument), was ordered Fowler's solution (mlv. ter die), and on 21st showed 48 only per square: continuing treatment, on September 11th

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there were only 37.3—the eruption was nearly gone (*Practitioner*, 1880).

The force and frequency of the heart's action and the activity of the capillary circulation are usually increased by minute doses (Feltz, Harless) and especially in weakly persons (*v.* p. 35) : larger quantities induce palpitation with quick, small, and irregular pulse ; the face is flushed, while the extremities are cold.

Poisonous doses markedly depress the circulation, and ultimately arrest heart-action (in diastole) in the lower animals, as found by Sklarek in batrachia and in cats—there was no previous stage of excitement (Reichert's *Archiv*, 1866). Although the frog lives on for ten minutes after arrest of cardiac action, no stimulus will re-excite this, and yet irritability of cardiac *muscular* tissue persists, so that Sklarek concluded that arsenic paralyzed the motor ganglia of the heart. Unterberger also records a very pronounced fall in the blood-pressure and pulse-rate (*Archiv. für Exper. Pathol.*, Bd. ii.). There is clearly a direct depressant effect on the heart—in fact, this causes death in cold-blooded animals, though not usually in warm-blooded. Some palsy of vaso-motor nerves is also indicated, and, according to several experiments, this is limited to the abdominal division of those nerves: the exact explanation, however, requires further development. Though Lesser verified Sklarek's observations he did not come to the same conclusion that arsenic causes death by paralysis of the heart, but denies it for the simple reason that frogs survive excision of the heart for more than thirty minutes, while arsenic kills them in ten minutes. Ringer and Murrell found (in frogs) a *varying* effect upon the heart, it being sometimes completely arrested, sometimes continuing to beat after complete general paralysis, but they explained the difference by a variation in dose; a large one being quickly absorbed and conveyed to the heart arrests it at once, leaving little for the circulation to distribute, while a small dose paralyzes the central nervous system before the heart (loc. cit.). In warm-blooded animals the pulse-rate was increased at first by small and medium doses injected into the veins, afterward it was diminished; by a large dose it was decreased at once, and blood-pressure reduced. The increase of the pulse-rate was traced to lessened influence of the vagus, and increased action of cardiac ganglia, the decrease of pulse-rate to contrary conditions. Stimulation of vaso-motor centres was not marked unless injections were made directly into the carotid, and Lesser could not verify paralysis of those centres under any conditions (Virchow's *Archiv*, 1878). In the human subject, the pulse usually becomes weak, rapid, and gradually more irregular till heart-action ceases : venous stasis naturally occurs, and there is pallor, lividity, and finally cyanosis of the surface and of visible mucous membranes.

Respiratory System.—Lesser verified a markedly stimulant effect of small doses, both on the respiratory centre and on the pulmonary ter-

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minations of the vagi; large quantities, on the other hand, extinguish nerve-irritability in these parts. That the effect is directly on the *centre* is clear from its occurrence even after section of the trunks of vagi, but when these nerves are entire the effect is greater, so that they have some share in it. Small doses taken under certain conditions—as, for instance, by the Styrian mountaineers—render the respiration easier, less labored, and less hurried under severe exertion. On the other hand, even medicinal doses, if long continued, will induce in some persons a dyspnœa, allied to that of emphysema or even asthma, with dry cough or hawking of mucus. This I have verified several times in the subjects of eczema, observing its cessation with the omission of the drug, and its return under arsenical influence; there may be also hoarseness, coryza, tonsillitis, or even, according to some observers, bronchitis (McCall Anderson), probably from irritation excited in the bronchial mucous membrane by the elimination of the drug; it has certainly some special determination to the pulmonary tract. After large poisonous doses the dyspnœa is often urgent, and the respiration stertorous.

Cutaneous System.—In frogs, one effect of arsenic is to cause a ready peeling or stripping of the whole cuticle some hours after hypodermic injection (Ringer and Murrell). In man, small doses, continued for a limited time, improve the skin-condition, and often (but not always) impart freshness and ruddiness to the complexion, while in animals they render the hairy coat more glossy and bright. Köhler remarks that since arsenic is eliminated by the sweat-gland (especially when they are acting vicariously for the kidneys), there is nothing remarkable in its modifying the circulation and nutrition of the skin, and its effects are explained by a capillary congestion and the presence of more blood in the superficial vessels, and this again has been attributed to a vaso-motor palsy allowing dilatation of such vessels.

Rabuteau thinks such a view cannot be accepted, because temperature is not raised as it is in experimental vaso-motor palsy—*i.e.*, after sections of sympathetic. This, I think, is a question of degree—the rise might be more or less according to the amount of paralysis induced by a drug—it would not be so complete as after section. Moreover, Harless reports a distinct rise, though recent experiments indicate a fall of temperature as the more *usual* condition connected with arsenical action (Lolliot). Rabuteau prefers to explain the florid color by an "altered appearance of the globules."

When the drug is omitted after continuous use, an opposite condition —one of pallor and anæmia—is said to follow (*Medical Times*, ii., 1854). Certainly arsenic, if long continued, leads to an unhealthy, dry, and somewhat scaly condition of skin, which has been called by some *pityriasis*, and by others even *psoriasis*, though I have never seen anything like a true case of the latter malady thus caused. Rabuteau observes,

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"We never see squamous affections from arsenic, contrary to the assertions of homœopaths" ("Elements," p. 200).

Perhaps the extreme and most characteristic cutaneous result of arsenical saturation is a brown color of the face and various parts of the body (Kirchgässer: *Centralblatt für Med.*, 1868). It is not common, but has been sometimes seen in such a form as to resemble argyria. Prof. Wilson gives the following illustration:—A lady had taken for fifteen months comparatively large doses of arsenic for gutta rosacea, and two months after commencing the medicine, a change of color had been noticed in the skin, first over the abdomen, then on the breast, neck, face, and hands. When seen by Prof. Wilson the face was yellowish-brown, the eyeball dark, the whole body colored more or less; chronic erythema affected the palms, there were hard dry points at the sweat-glands, the eyelids and the extremities were œdematous (*Journal of Cutaneous Medicine*, vol. i., p. 354). In some of Mr. Hogg's cases, children got a "dusky skin-eruption in patches" from arsenical wall-papers (*British Medical Journal*, i., 1879). Such a condition depends not on chemical combination (as with silver) but on abnormal pigmentation (Gubler).

Cold clammy perspirations have also been connected with arsenical action, and pustules and ulcerations have sometimes followed it. In acute cases, either of poisoning or of unusual susceptibility to the action of the drug, patches of erythema or of urticaria (local congestions of skin) and even acute general lichen may occur. Macnab recorded an eruption like measles produced by 3-min. doses of Fowler's solution daily for three weeks (*Medical Times*, i., 1868), and Wyss says that he traced to it a case of alopecia areata—from affection of the trophic nerves of hair-follicles (*Archiv der Heilk.*, 1870, Hft. i.).

Among rarer consequences, erysipelas with bullæ has been credited to arsenic, herpes has been traced to it by Mr. Hutchinson, and an obstinate eczema by Dr. Balfour (*Edinburgh Medical Journal*, 1860). Dr. Imbert Gourbeyre has specially written on arsenical eruptions, and, in cases of acute poisoning when the patient survived several days, has seen them petechial, papular, vesicular, and pustular.

A degree of cutaneous swelling, characteristic enough to have received the name "*œdema arsenicalis*," usually occurs first about the eyelids and suborbital tissues, and is one of the earliest symptoms of constitutional action. In severe cases it may affect the extremities and even the trunk, and amount to general anasarca, as recorded so early as 1819, (*Edinburgh Medical Journal*, v., 15). In Dr. Feltz's cases already referred to, there occurred, on the second or third day, swelling of the eyelids and conjunctivæ—in some instances of the whole face, with a rash like scarlatina or urticaria. In most of them there was itching of the surface, and scratching gave rise to an urticarial rash; in one man the same eruption, together with herpes, appeared on the scrotum.

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Mucous Membranes.—We have already noted characteristic arsenical effects upon the membrane of the mouth and intestinal canal. The lips, the nose, especially at its orifice, the anus, and the vulva often become similarly irritated and inflamed, and urethritis has been traced to medicinal doses of arsenic (*Medical Record*, 1878). On the mucous membrane of the *eye* the effect of the drug is often very early seen, so that it becomes a useful index of the degree of physiological action. Itching about the lids is first complained of, and a rough sensation as of dust in the eye; the conjunctiva is seen to be congested, and purulent secretion may be formed. Conjunctivitis is a frequent symptom in arsenical poisoning, and Dr. Taylor describes "tumid, everted lids and painful vision" in patients affected by arsenical papers, etc. (*Ophthalmic Hospital Report*, 1859, and *British Medical Journal*, ii., 1871).

Glandular System.—Under small doses of arsenic the secretions are increased, especially of those glands by which the drug is eliminated. Increase of quantity of the saliva is exceptional in acute poisoning, but occurs when absorption takes place slowly and gradually. The bile, the intestinal secretions, and, generally speaking, the urine are augmented under its use; and if there be no diuresis the perspiration is commonly stimulated, and arsenic can be detected in it (Kohler: *Handbuch*, p. 724). Hoffmann, Glauber, Agricola, and Pott have even recommended arsenic for a diaphoretic effect, and I have myself sometimes observed this from it.

Osseous System.—Struck by Wegner's observations on bone-changes under phosphorus, and following up the paper of Maas, "On the Influence of Arsenic in Bone-growth, and its Value in Surgical Therapeutics" (1872), Th. Gies has recently published some careful and interesting experiments which well illustrate such influence (*Archiv für Exper. Path.*, etc., Bd. viii., Hft. iii., December, 1877). Using at first young rabbits badly nourished, he found that arsenic destroyed them *without* causing bone-change; but having, by careful food, secured for fresh animals apparently more resisting power, the same daily doses (0.005 to 0.002 gramme arsenious acid) continued for nineteen to thirty-four days, seemed to improve their condition, as compared with rabbits from the same litter, and fed in the same manner (but without arsenic): the former were larger, heavier, with clearer skin, and healthier-looking than the latter, and after death the respective bones could be at once distinguished. In the long bones of the arsenic-eaters was a special thick layer (arsenschichte) of bone between the epiphysis and the shaft; the shaft also was thicker, and in bones, such as the ribs and the vertebræ, the structure was much more dense, and harder to divide, than in normal animals; the new structure was true bone, but the bone-corpuscles and Haversian canals were smaller than the average. Comparative experiments were made with many rabbits, cocks, and pigs, and in such manner as to

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leave no doubt whatever that increased growth and condensation of bony tissue were traceable to the action of arsenic. In old animals, where epiphyseal growth had ceased, increase of thickness of bones occurred; on the other hand, if the doses were increased beyond a certain point, resorption of bone occurred, and symptoms of poisoning set in. Bones purposely fractured had not united under the treatment, for their small size made it impossible to keep them in position, but a false joint formed, and much callus was round the broken ends; there was fatty degeneration of all internal organs. Gies does not adopt Wegner's view of increased stimulus given to bone-formation, but rather that of Cunze and Lolliot, that arsenic diminishes tissue-change, especially as regards carbohydrates, and hence follow increased deposit and insufficient removal of organic particles.

Genital System.—This system often shares in the general stimulation and irritation induced by small doses of arsenic, as has been noticed in the arsenic-eaters of Styria, and in experiments on animals. Gies especially remarked it in the cocks used for his observations on bone-growth (loc. cit.). Clinically, Prof. Charcot was led in two cases to a contrary conclusion, but Devergie showed that this could not be sustained, and that stimulation to some extent was not unusual (*Bulletin de Thérapeutique*, 1864); this, however, is not such as to preclude the medicinal use of the drug, and it finds its place in the treatment of amenorrhœa.

In *arsenical poisoning*, inflammation of the genitals has been said to occur (Hunt), and certainly much irritation of them has been present, especially in women; but it would seem to be connected rather with the general irritation of mucous membrane than with these special organs. The young of animals subjected to an arsenical course were born dead, but fully developed; their birth was delayed rather than premature (Th. Gies, loc. cit.), and no markedly injurious effect can be traced on the uterus. In many instances of arsenic being taken by pregnant women, even when with fatal results, abortion has not occurred (*Guy's Reports*, vol. vii.).

Urinary System.—The urine is commonly increased in quantity for a time under small doses, but with their continuance renal irritation may be induced, so that the secretion is lessened, and elimination of the drug impeded. Hence it is an important practical point to examine the urinary condition during arsenical treatment, and to use, if necessary, alkaline diuretics. Lolliot traced hæmaturia and albuminuria to arsenic, and, in a case of pythisis, carefully recorded by Dr. Weir Mitchell, albuminus urine was induced by 4 to 12 min. of Fowler's solution given daily for a few weeks; anasarca also set in, and these conditions ceased and then recurred concurrently with omitting and resuming the medicine (*New York Medical Journal*, vol. i.). After poisonous doses the urine, though at first it may be passed too often, soon becomes scanty, and its evacuation

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causes scalding pain and tenesmus; it may contain blood, albumen, and casts, and sooner or later becomes suppressed; urethritis has been already mentioned.

Urinary Excretion in Relation to Tissue-change.—The estimation of urea and other constituents of the urine furnishes important evidence as to the influence of arsenic upon general nutrition and tissue-change, for it is clear that if the principal urinary ingredients are increased under its use, tissue-changes must be going on rapidly, and *vice versâ*. There has been some contradiction between observers on these points. Sabelin recorded *increased* excretion of urea under arsenic (from 12 to 28 gr.); also marked increase in the chlorides and earthy phosphates, and proportionate diminution of uric acid—an incompletely oxidized product (hence G. Sée argued that the drug favored oxidation and promoted metamorphosis ("Nouv. Dict.," Art. Asthme)—he has, however, himself since withdrawn these views). Fokker published two analyses showing a slight increase of urea after 0.01-gramme doses (Schmidt's *Jahrb.*, Bd. clviii.), and Gaethgens recorded the same in two dogs taking soda arseniate; also decidedly increased tissue-change under toxic doses (*Centralblatt für Med.*, 1875, No. 32, s. 529, and 1876, No. 47, s. 833). Binz and Schulz, relying upon these observations, and noting also that hypodermic injection of arsenious acid did not produce a local caustic effect but inflammation in distant organs—*e.g.*, the stomach—have recently argued that "this substance, in contact with living protoplasm, acts in the tissues as an oxidizing agent or carrier from one albuminous molecule to another, being converted during this process into arsenic acid, then reduced, again oxidized, and again reduced" (*Centralblatt für Med.*, ii., 1879; *Medical Times*, i., 1879). But I think the evidence insufficient for the conclusion, and all observations upon fasting animals are open to the fallacy that *urea may be increased by the fasting*, and consequent absorption of fat (Forster: *Zeitschrift für Biologie*, xi., s. 522). The dogs utilized by Gaethgens were kept many days on water only, and a careful examination of the whole question leads to the conclusion that the "tissue-change of inanition" is almost surely the explanation of what he attributed to arsenic (F. A. Falck: *Archiv für Exper. Path.*, August, 1877, Bd. vii.). Von Böck attributed any change he could observe to the effect of fasting (*Zeitschrift für Biologie*, vii., s. 418–432), and held that arsenic acid in ordinary doses exerted no essential influence on tissue-change.

Others have concluded positively that it *lessens* excretion and change. Thus Lolliot, in a careful thesis, records many observations and analyses, from which he makes evident a *diminution* of urea and carbonic acid under arsenic; he asserts, also, that it lowers temperature, and is a "médicament d'épargne"—it lessens the activity both of nutrition and denutrition ("Étude Physiol. de l'Arsenic," Paris, 1868). Köhler classes it with tea, coffee, cocoa, as "sparmittel"—diminishing oxidation processes

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(*Handbuch der Physiol. Therapeutik*, 1876). In recent experiments by Dr. Tamassia (Pavia), toxic doses of white arsenic given to animals, progressively lowered temperature up to, and after death (*Medical Record*, January, 1878). Animals accustomed to an arsenical ration became pyrexial and emaciated on its withdrawal, implying that some moderating power had been removed. There is still, however, a discrepancy in the observations on temperature; Harless reported a slight rise from small doses, and Billroth, gradually increasing the dose to 40 min. daily in a case of asthma, reported a febrile access in the evenings up to 101° F. (*Wiener Woch.*, 1871, No. 44).

Schmidt and Brettschneider found the excretion of urea and of carbonic acid under arsenic diminished 20 to 40 per cent.; phosphates also diminished. Schmidt and Stürzwage likewise report diminution of carbonic acid and urea in rabbits under minute doses (Schmidt's *Jahrb.*, Bd. clviii., pp. 13–15), and Rabuteau states that the elimination of urea in a dog was lessened for three weeks after a few doses of arsenious acid, at one time as much as 60 per cent.; he attributes its effect in lessening tissue-change to an action on the blood-corpuscles.

I conclude that although some contradiction exists on this point between good authorities, yet the balance of recent evidence points to *lessened excretion*, and consequently to *lessened tissue-change* as an effect of arsenic.

Acute and Chronic Poisoning.—Although not here concerned with cases of poisoning further than as they illustrate physiological action, we may note that if death occurs from large doses of several drachms, and in the course of a few hours, it is generally from *cardiac palsy*, and is preceded by excessive prostration and fainting. If 1 or 2 dr. have been taken, and the patient survives two or three days, the symptoms will be mainly those of *severe gastric and intestinal* inflammation, as already described, and the post-mortem appearances will correspond; while with doses of 2 to 10 gr., when the patient survives much longer, and yet dies ultimately from the effects, these will be evidenced rather in the *nervous system* (Hunt). If the poisoning be very chronic, and result from continued doses of $\frac{1}{8}$ to $\frac{1}{4}$ gr., a general irritation of the system is apparent from the symptoms of erethism or pyrexia with chills, redness of eyes and of orifices of nose and anus, vesication on palms and soles, with dryness of skin and brownish spots, pain in head and joints and abdomen, with vomiting, purging, and gradual marasmus. The soreness of mouth and salivation have sometimes suggested *mercury* as the poisonous agent, and sometimes the general condition has been mistaken for phthisis, or for typhoid. Gaethgens further suggests points of resemblance with diabetes and with phosphorus-poisoning (*Centralblatt für Med.*, 1875, Bd. xiii., p. 32, Abstract in Schmidt, 1876). An instructive case which, for a time, completely deceived the medical attendants, and yet which

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reveals exactly the physiological action of arsenic as we have described it —including renal and nerve-symptoms—is that of Mrs. Wooller as collated by Sir R. Christison (*Edinburgh Medical Journal*, 1855).

Pathological Changes.—In cases of acute poisoning, the principal changes occur in the stomach and intestinal tract; redness and inflammation of these parts may be found within a few hours of administration; ulceration is not uncommon, gangrene and perforation are rare. In exceptional cases no marked redness has appeared, though arsenic has been found in the stomach (Taylor). Under full arsenical influence there is marked tendency to fatty degeneration of all tissues; in acute cases this is preceded by inflammatory change, and according to Dr. Pinkham (Boston) it may be induced within forty-four hours (*Medical Times*, ii., 1878). Jaundice occurs, and after death the liver-cells, the renal tubules, and the intestinal glands are found choked with granules and fat-globules, their epithelium being detached or destroyed. Salkowsky found these changes in poisoned animals within three to six days, the glycogenic function of the liver being impaired very early (Virchow's *Archiv*, Bd. xxxiv.); it is noteworthy that in such cases the fourth ventricle may be punctured without causing glycosuria. Virchow described a swollen state of Peyer's patches and the solitary glands, with fatty degeneration of epithelium and "rice-water" secretion containing a fungus that had been thought peculiar to cholera (*Archiv*, Bd. i., 1870). C. Gies has recently given additional evidence of fatty degeneration of tissue under continued small doses of arsenic, but notes also that the subcutaneous fat was increased, and the animals gained weight. Increase of fat and of weight have been observed in chronic arsenical poisoning in man (*Boston Journal*, 1876).

Tolerance.—*Arsenic Eating.*—Under certain conditions the system may be brought to "tolerate" full, and even toxic doses of arsenic as of some other drugs, without showing the usual physiological effects. To produce such result, it is necessary to begin with very small doses, and increase them by degrees: thus Flandin, giving at first $\frac{1}{6}\frac{1}{5}$ gr. of arsenious acid to animals, gave, after nine months of progressive increase, 15 gr. per diem without poisonous symptoms (quoted by Stillé).

Taylor distinguishes between "*habit*" and "*tolerance*," meaning, by the latter term, only that power of bearing large doses which is shown in certain exceptional states *without any preparation;* thus, opium may be tolerated in tetanus, alcohol in fever, and antimony in pneumonia; and with regard to the ordinary form of tolerance as *induced by habit*, he remarks that it is mainly restricted to products of the vegetable or organic kingdom—as opium, tobacco, ether, strychnia. He doubts whether any human being can obtain *by habit* any real tolerance of such mineral drugs as corrosive sublimate and arsenic; and certainly experiments on the point can never be pushed far in our own experience.

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Yet, on the other hand, evidence in the affirmative does exist. I understand that at Whitbeck (Cumberland) the inhabitants habitually use a natural water which contains nearly a grain of arsenic in the gallon, and are remarkably healthy and long-lived (*Chemical News*, August, 1860). Professor La Rue reports the case of a man who so far accustomed himself to the drug that he could take 3 or 4 gr. "without more effect than cold water" (*Boston Medical and Surgical Journal*, 1866); but the main evidence seems curiously localized in parts of Austria and Styria, nor can it be any longer dismissed as "pure fable" (Christison) or a "Styrian theory" (Taylor), since the reports of Vogt and Tschudi in 1854 (*Medical Times*, ii.; *Wiener Med. Woch.*, No. 28). M. Heisch, a trustworthy witness, has recorded his personal experience to the effect that he took 3 gr. as a daily dose for many years; he began it, when appointed director of arsenic works at Salzburg, with the object of protecting himself from the effects of the fumes; he retained good health, but when he attempted to leave off the drug suffered from restlessness, insomnia, faintness, and finally from lung-symptoms (*Lancet*, 1860). Professor Schäfer records that $\frac{1}{20}$ to $\frac{1}{10}$ gr. is an initial dose commonly used for the first fortnight, then it is omitted for the same period, and then resumed and gradually increased to 5 gr. or more (Nothnagel, p. 241)—Heisch says that 23 gr. have been taken for a dose. Arsenious acid is the usual form, but sometimes orpiment is substituted. Dr. Maclagan saw doses of several grains swallowed, and he afterward detected arsenic in the urine (*Edinburgh Medical Journal*, 1864); and I have myself learnt from persons at Salzburg that the habit was very common, and have seen men who had taken from 5 to 10 gr. daily for many years, with occasional intermissions, and who looked robust and healthy. Near Harzburg they have the curious custom of regulating their doses by the moon—they gradually increase to the full moon, and then diminish and take purgatives of aloes: some avoid drinking with their dose of arsenic, others avoid fat, and others keep to a farinaceous diet, but the majority eat and drink anything. The practice prevails mostly, if not entirely, among the working-classes, but is not confined to men. Its effect is said to be to increase fat and stoutness, and yet to render them more equal to exertion, and especially to mountain-climbing without difficulty of breathing; also to give freshness to the complexion, brightness to the eye, and general vigor to bodily function.[1] It is agreed that much depression and emaciation occur on the withdrawal of the drug from those who are accustomed to it, and although a certain number who commence early to

[1] Gubler explains these effects by diminished oxidation and tissue-change (*v.* p. 40), suggesting the connection of muscular fatigue with formation of sarco-lactic acid; he presumes this to be lessened by arsenic alike in thoracic, respiratory, and other muscles. They can therefore work longer, there is less carbonic acid to be discharged by the lung, and less labor or hurry in respiration.

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take it continue its use to an advanced age, yet it is said, and we can well believe it, that it does much harm and even proves fatal in an insidious manner to many persons, especially among the young. We cannot depend upon securing an indiscriminate tolerance of arsenic; nothing of the kind has been reported in this country, but on the contrary many have suffered from a foolish imitation of the Styrian custom.

Effects of Arsenical Wall-Papers, etc.—It is now clearly ascertained, though the knowledge is comparatively recent, that all the serious symptoms already described may be produced, in greater or less degree, by arsenical emanations from wall-papers and paints, hangings, dresses, ornaments, etc.; and not only from the green colors containing arsenite of copper, and which have long been suspected, but also from red, drab, blue, gray, and enamel papers generally (*British Medical Journal*, ii., 1871), and from aniline colors fixed by arsenical mordants in carpets, curtains, etc. (Taylor: "On Poisons," 3d Ed., p. 353). Soon after the earliest observations on the subject, in 1858, Mr. Phillips (the chemist consulted by the Board of Trade) stated that a more than bearable heat would be required to volatilize arsenic, but Fleck has pointed out that the contact of moist organic substances (such as sizing) readily disengages arseniuretted hydrogen from Schweinfurt green (*Zeitschrift für Biologie*, Bd. viii., 1872), and Hamberg has verified its presence in the air of rooms (*Pharmaceutical Journal*, August, 1874). This gas is a very powerful poison. Gehlen, the chemist, was killed by a small quantity, and in some recent cases it caused severe epistaxis, hæmaturia, and jaundice (*Comptes Rendus*, 1863; *Gazette de Paris*, No. 18, 1873). Usually, however, the injury is done by material particles of arsenical dust (Chevalier: *Annales d'Hygiène*, vol. xii., p. 49). Some time ago I met with many cases of catarrh, irritation of mucous membrane, etc., which proved to be due to this cause, and I can quite corroborate the observations made by Mr. Clarke, of Bristol (in a careful paper in *British Medical Journal*, i., 1873), who finds that in one set of cases dyspepsia, nausea, sore throat, and conjunctivitis are the prominent symptoms, while in another nerve-troubles, headache, irritability, prostration, and restlessness are more complained of, though dyspepsia, and especially coated tongue, are not absent; in a third group the prostration, headache, and nervous excitement simulate a mild typhoid. He records violent sneezing, and also an eruption of eczema and of nasal ulceration as exceptional symptoms, and further points out that a case of ordinary illness may be much aggravated by an arsenical atmosphere, and that some patients are much more sensitive to it than others. Arsenic was detected in the secretions of several of Mr. Clarke's patients. The symptoms are generally worse in a damp atmosphere, and in the evening when the room is heated. Dr. Hinds describes "depression, faintness, nausea, and colic," after reading by gaslight in a green-papered room (*Medical Times*, 1857). Mr. White-

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head reports similar symptoms in a youth every time he occupied a certain bedroom only (*British Medical Journal*, 1858).

The real cause of chronic ill-health may be long unsuspected, and a striking case is related of the simulation of various forms of disease in one family for upward of twelve years before their true cause was discovered in arsenical wall-papers (*British Medical Journal*, ii., 1871). Dr. G. Johnson has reported the case of a medical practitioner, in whom chronic dyspepsia, catarrh, cough, and even asthma were due entirely to the same agency (*Medical Times*, ii., 1874). Similar symptoms have followed, though less frequently, from painted walls, gas-shades, etc. (Basedow, in *Monthly Retrospect Medical Science*, 1849; *New Sydenham Society's Year Book*, 1860, etc.). Dr. F. Brown (Boston) has reported several interesting and important cases of chronic illness from arsenical paints and wall-papers: he notes that most of the patients had increased in weight (*Boston Medical and Surgical Journal*, 1876). Some years ago arsenic was purposely used for clarifying candles, and thus serious effects were produced, which still sometimes follow the use of candles colored green. Arsenical poisoning has occasionally occurred from cigars (*New Sydenham Society's Year Book*, viii., p. 432), and from green cigar-holders (*British Medical Journal*, i., 1879). Mr. Jabez Hogg has drawn special attention to eye-inflammation from arsenical papers and to other illnesses produced by them (*Sanitary Record*, April, 1879).

Synergists.—Antimony is the most complete analogue of arsenic, except that the former is a more certain emetic: phosphorus also is allied in action.

The effect of small doses, upon the nervous system especially, is allied to and supported by quinine and by alkaline bromides, while the tonic influence of similar doses on the vaso-motor nerves (leading to contraction of vessels, at least temporarily) is allied to that of acids, astringents, ergot, and cold applications. Doses sufficient to lessen oxidation and combustion act somewhat like cyanides and other substances which prevent these processes.

Antagonists — Incompatibles. — Diffusible stimulants, alcohol, warmth, and, according to Gubler, opium, are the vital antagonists to arsenic. Iron, in the form of hydrated peroxide, magnesia, calcined or as hydrate, lime, animal charcoal, and astringents generally, are chemical or mechanical antidotes. Iron and magnesia have power over arsenic in *solution*, since they precipitate the poison in an insoluble form; with *solid* arsenic "they have no more effect than powdered brick-dust" (Taylor). A mixture of hydrate of magnesia and persulphate of iron is best to use, and the resulting sulphate tends to act on the bowels. The "antidotum arsenici" of the German and other Pharmacopœias contains calcined magnesia 7 parts in 120 of water, solution of persulphate of iron (sp. gr. 1318) 60 parts in 120 of water: the two parts to be kept separately and

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mixed at the moment of administration. Pure dialyzed iron is not antidotal, but according to Mattison becomes serviceable if salt be added to it (*Medical Record*, 1878), since this precipitates a hydrate.

In cases of poisoning, vomiting should be produced and promoted as early as possible, by ipecacuanha or zinc sulphate: nor is antimony so undesirable as has been stated; many cases have recovered under its use (Morgagni, and *Gazette des Hôpitaux*, August, 1844, etc.), also after infusion of tobacco (*Medical Times*, i., 1857). Milk and demulcent drinks containing, *e.g.*, eggs, flour, or fats, should be given, and large frequent doses of any of the antidotes named, a tablespoonful of the iron compound every five to ten minutes (*British Medical Journal*, ii., 1863).

THERAPEUTICAL ACTION (EXTERNAL).—*Parasitic Diseases.*—In scabies, and in phtheiriasis, arsenic has sometimes been used, and a lotion containing a small proportion [1] with soft soap and spirit of wine has been much commended: it is painful in application, and has not seemed to me so good as other remedies; neither is the use of this substance free from danger, for an arsenical salve applied for scabies has produced poisonous effects.

For *ascarides* Trousseau recommended an injection of ¼ gr. of white arsenic in 4 oz. of water; it is not often used, but would probably be effective. M. Boudin used the same remedy in larger doses, but it is unnecessarily dangerous.

Lupus—Cancer.—In these maladies the caustic action of arsenic is often extremely valuable, and the powdered drug may be used sufficiently strong to destroy diseased tissue without affecting the adjacent sound skin. For chronic superficial lupus, especially of the face, Hebra recommends "Cosme's paste," containing 20 gr. of arsenious acid and 60 gr. of cinnabar in 1 oz. of rose ointment (cold cream): this is spread on linen, and applied firmly for twenty-four hours, and then renewed for the same period, a third application being made if required. I have often used this with good results; at first there is little change produced, but by the second day the growth turns gray, and by the third day commences to slough, and may be separated in a poultice. Pain and œdema may occur, but can be relieved by sedatives and warm applications. Among many hundred cases thus treated no poisonous symptoms have been reported.

In *epithelial cancer* arsenic has long been used. Rousselot combined it with cinnabar, and Dupuytren with calomel, and Mr. Marsden has written in praise of its association with an equal part of mucilage. The paste commonly known in Ireland by the name of Miss Plunkett's is prepared with arsenious acid, sulphur, and two species of ranunculus: it often acts powerfully.

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[1] Arsenious acid 1 part, carbonate potash 20 parts, soap spirit 200 parts, water 2,000 parts. (Soap spirit is made with equal parts of soft soap and spirit of wine.)

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As already stated, caution is required in the external use of arsenic: not that it should be applied in a more diluted form, for then its absorption would be even more probable, but only a limited area—not more than one square inch—should be covered at one time. Dr. Walshe has specially insisted that its use should be restricted to superficial cancer. From the internal administration of arsenic I have had good results in epithelioma (*v.* p. 66).

Dental Surgery.—Arsenious acid is in daily use for destroying the nerve-filaments in a tooth-pulp before filling the cavity, and it is still considered one of the best agents for the purpose. It is true that violent symptoms have sometimes followed its use, which always needs caution: still osteitis and its accompanying pain might occur after any destructive application, and we may fairly consider that $\frac{1}{10}$ gr., especially when combined, as it usually is, with a little morphia, is free from any serious risk of arsenical irritation.

Rheumatic Gout.—Baths containing from 15 to 30 gr. of arseniate of soda, with a few ounces of the carbonate of soda, have been well spoken of by Dr. Guéneau de Mussy, as relieving both the pain and the deformity consequent upon rheumatic arthritis. There is some evidence in favor of the internal use of the remedy for this malady (*v.* p. 51).

THERAPEUTICAL ACTION (INTERNAL).—The therapeutical powers of arsenic, which are many and various, may be traced along the same lines as its physiological action, and without implying any definite limits as to the pathology of the under-mentioned diseases, we may, for the sake of clearness, arrange them in four groups for consideration in detail:—(*a*) General or blood-diseases, such as intermittent fever, phthisis, struma, lymphoma, anæmia, chronic rheumatism, diabetes; (*b*) more specially nerve-disorders, neuralgias, asthma, chorea, tremor; (*c*) disorders connected mainly with capillary congestion, cerebral, renal, uterine, or cutaneous; (*d*) disorders affecting chiefly mucous membranes, coryza, chronic bronchitis, dyspepsia, gastric catarrh, vomiting, diarrhœa, English cholera, gastric ulcer.

Intermittent Fever—Ague.—Long used as an empirical remedy for ague, in the East, its more scientific employment dates from Slevogt, of Jena, in 1700.[1] Condemned by Baron Störck, it was reintroduced by Dr. Fowler, of Stafford, in 1786, after experience of the effects of a "patent ague drop" which contained it; and again condemned by Brous-

[1] Of the older writers on this subject, Melchior Frick, and the two Plencitz, of Vienna, deserve mention. The former says—"Experientia nos docebit, arsenicum in febribus intermittentibus adhibitum omnes eas dotes possidere, quibus optima remedia prædita esse debeat" (Paradoxa de Venenis, 1710). Of the practice of the latter at the Orphans' Asylum, Harless reports—"Ejusque (arsenici) usu in millenis fere febrium intermittentium casibus, raro frustratos fuisse affirmant."

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sais. Its value was finally re-established by Boudin, in 1842, after a prolonged experience in Algeria ("On Intermittent Fevers," Paris, 1842). The English physician reported several hundred, but M. Boudin, four thousand cases, almost all successful. The former was accustomed to press the remedy to its "operative" or physiological effects; the latter aimed at inducing "tolerance," commencing with fractional doses every quarter-hour, so as to introduce as much as possible into the blood, and to "substitute an arsenical for a paludal saturation." The names of Sistach, Millet, Fremy, and Isnard are associated also with records of large numbers of successful cases, while opposite experiences may be found in the works of Gintrac, Oesterlen, and G. Sée.

In 1860, Mr. J. Turner reported such favorable results with ½-dr. doses of Fowler's solution, given every second hour for four or five doses, that the Director-General recommended the plan to army officers (*Medical Times*, ii., 1871), and Dr. Chappell supported it with an account of eighty cures out of one hundred and forty cases (*Medical Times*, i., 1861). The same dose was used by Dr. Broderick, but not without sickness (*British and Foreign Review*, 1866). These observers found, as did Fowler, Rayer, and others, that much better results in curing ague were obtained with large doses, as of 30 to 40 drops, than with ordinary, full, or unusual doses up to 20 drops; but Sistach and others observed that as soon as the fever ceased, the system ceased to "tolerate" such quantities, and there is always a possibility of the remedy doing harm. Quite recently has been recorded the case of a physician, aged fifty, who took 12 drops of Fowler's solution twice daily for about three months with apparent benefit to the intermittent, but he got diminished secretion of urine, colic, tenesmus, weak heart, etc., and died rather suddenly with vomiting and syncope; his attendant (in South America) traced his symptoms to arsenic, and Dr. A. S. Taylor concurs. It must be said, however, that an ordinary cerebral attack—*i.e.*, independent of arsenic—is not excluded by the history given (*Medical Record*, February, 1879).

We cannot doubt that arsenic, suitably administered, is an effective remedy for ague, but on comparing it with quinine, and allowing for a percentage of spontaneous recoveries from mild attacks, we conclude that the latter remedy is still to be preferred for severe and acute cases, and in "pernicious" or "malignant" forms; also it acts better usually in tertian ague. When, however, it has failed to cure such cases even in excessive or long-continued doses, or when the malady is of moderate severity, subacute or chronic, especially of quartan type and accompanied with marked œdema and prostration, then arsenic is specially indicated. The element of risk may be much lessened by careful attention to the urine and the general symptoms.

Splenic or hepatic hypertrophy may be another indication for it, as Boudin suggested. It is good in malarious cachexia (when quinine often

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renders but little service), also when jaundice is present; further it has some prophylactic power, and assists in preventing relapse.

I have records of nineteen cases of severe chronic ague of the quartan type, all successfully treated by arsenic. Most of the patients were Americans who had taken quinine very largely, being in the habit of carrying it in their pockets and taking from 5 to 20 gr. whenever they fancied an attack was impending. Many of them had clean, red, irritable tongues, and were suffering from œdema or anæmia; in most of them the spleen was enlarged, and in some the liver. I prescribed the liquor arsenicalis in 5 to 10-min. doses thrice daily, and the result of this treatment was uniformly good. Both quinine and arsenic have been credited with an "anti-zymotic" power of destroying malarial germs in the blood. As regards the prevention of relapse, Hirtz, judging from 120 cases, found quinine and arsenic nearly equal; probably the best results may be obtained by a judicious combination of them both, full doses of the former being given to ward off an impending paroxysm, and arsenic in the intervals: this mode of treatment I have frequently adopted with success. Prof. Gubler uses arsenic in ague as a sedative, and "indirect reconstituent," and connects its anti-relapse efficacy with its permanent deposition in the tissues.

Phthisis.—For the employment of arsenic in chest diseases we may go back as far as Dioscorides, who states that "sandarach" (probably the sulphuret) "is given to patients suffering with lung-suppuration, and mixed with resin is inhaled in vapor for obstinate cough." Dr. Beddoes used it early in this century, and recently the value of the drug in certain stages of tubercular phthisis has attracted renewed attention. Hérard and Moutard-Martin have especially recorded good results from it in relieving the lung-congestion and the general pyrexia of early stages; at the same time the latter physician observes that it is most efficacious when phthisis assumes a *slow* torpid course, acute tuberculosis not being modified by it. "It has a reconstituting action, and modifies secondarily the pulmonary lesion" in suitable cases (*Lancet*, i., 1868).

Before suppuration of tubercular deposits has taken place, I have found arsenical solution in 2 or 3-min. doses, three times daily, give particularly good results; it is well to combine it with a course of cod-liver oil and change of climate, and it should be continued for weeks or even months if possible. I agree with the account given by Isnard (which is still more favorable), for he found it relieve profuse sweatings, improve appetite, and promote in some favorable cases not only healing of cavities but absorption of tubercle (*Bulletin de Thérapeutique*, t. lxxvii.). It controls diarrhœa in these cases in a very marked way.

Cersoy traces to arsenic an effect which has been also attributed to it in bronchitis, and which really accords with what we know of its physiological action—viz., the lessening of congestion both in the bronchial

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mucous membrane and in peritubercular lung-tissue; thus he finds that it benefits hæmoptysis (*Gazette des Hôpitaux*, 1869). Prof. Stillé thinks it probable that any benefit conferred in phthisis is due to an influence upon the accompanying bronchitis.

Massart is almost alone in his recommendation of an *arseniate of gold*, which, in doses of $\frac{1}{10}$ to $\frac{1}{8}$ gr., he found useful even in advanced cases (*Revue de Thérapeutique*, 1860, p. 21). The general opinion of French observers, however, would restrict the value of arsenic to early stages, or to the relief of certain symptoms: thus Nouat agrees as to the good results of $\frac{1}{10}$ to $\frac{1}{30}$-gr. doses given early in the malady, and finds that in later stages, especially in the cases mostly seen in hospital practice, benefit is exceptional (*Lancet*, i., 1870); and Trousseau, while recording improvement as to diarrhœa, hectic, expectoration, and cough, does not speak of cures, but of the gradual development of the malady and the formation of fresh tubercle. He prescribed cigarettes containing arseniate of soda, and pilules of arsenious acid.

I do not find many English observations on this subject, nor has this medication for phthisis been generally adopted among us. Dr. Williams says, "I have tried it only to a limited extent. . . . . It has only seemed to be useful in chronic cases with asthmatic or cutaneous complication, but well deserves further investigation" ("Pulmonary Consumption," p. 362). Dr. Ringer suggests that allowance must be made for a natural improvement in some forms of phthisis, but has himself seen instances of recovery under its use "in children with general tuberculosis," and "in adults suffering from subacute and chronic forms." He corroborates also, to some extent, the statement that it will reduce temperature (Handbook). Dr. Sanger reports, from the convalescent hospital at Seaford, favorable results in a large number of phthisical patients to whom he gave 5-min. doses of Fowler's solution, but he generally combined it with iron or hyposulphites (*Lancet*, i., 1869). Dr. Leared based a favorable opinion upon observation of nine cases, but finds the remedy "trying to the digestive system" (*Medical Times*, i., 1863), and this I believe to be a very common result owing to the dose prescribed being too large. Dr. Bartholow, without offering detailed evidence, affirms that "we have no single drug of equal utility in the chronic forms of phthisis, but it is not serviceable in caseous pneumonia . . . . neither is it beneficial when much hectic is present with rapid disintegration of pulmonary tissues."

Struma—Strumous Ophthalmia.—In chronic cases of glandular enlargement, pallor, and anæmia, occurring in subjects with the ordinary evidences of struma, arseniate of soda is often beneficial; it improves appetite and color, seeming to stimulate the lymphatic and arterial systems. I have frequently known Fowler's solution prove serviceable in strumous *ophthalmia*, giving relief to the redness and swelling of lids, as well as to

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conjunctival congestion and excessive secretion. It has seemed also to help in cicatrizing ulcers, and in diminishing the exudation which would produce leucoma. Mr. Oglesby speaks of its special value in that form of strumous ophthalmia which is accompanied by herpes (*Practitioner*, vol. ii.).

Strumous Cachexia—Lymphoma.—Prof. Bouchut restricted the value of arsenic in glandular disease to cases where this was superficial and limited, and where cachexia was not present, but later experience has proved the remedy to be more generally useful than he believed. I have seen it of much service, especially when combined with iron, in relieving cachexia, and Billroth has recorded a remarkable case—that of a woman, aged forty, in whom the cervical, axillary, and other glands, as well as the spleen, were affected, and who recovered under Fowler's solution, taking 5 to 20 drops for a dose. Billroth's observations have not been often repeated, but have been recently supported by Dr. Winiwarter. He records good results in cases of malignant lymphoma, or Hodgkins' disease, a malady limited to lymphatic structures, and to be distinguished from a sarcoma commencing in the glands, and spreading from thence. In the latter condition arsenic has no influence: neither is "Hodgkins' disease" to be confounded with scrofula, for there is no tendency to suppuration; nor with leukæmia, for there is no increase of white corpuscles. The malady referred to occurs in strong young persons, often begins in the cervical glands, which enlarge separately, and it is fatal if left untreated; it has been observed to follow intermittent fever. Under the use of arsenic, continued for three or four months or more, and also injected into the tumors, they have disappeared, at least for several years, and the patients have become convalescent. It is recommended to begin with 5 min. of Fowler's solution and 5 min. of tinct. ferri night and morning, cautiously increasing the dose up to 30 to 40 min., or to the production of physiological effects (Stricker's *Jahrb.*, 1877, part ii.).

Chlorosis.—In this disease arsenic often acts particularly well, and has been strongly recommended by Isnard.

Progressive Pernicious Anæmia.—The remarkable and serious malady now known under this name, and which was first described by Dr. Addison as "idiopathic anæmia," has proved sometimes amenable to arsenic. It occurs often, without appreciable cause, about or beyond middle age, the patient becoming blanched and waxy-looking, sometimes jaundiced, and suffering later from œdema, dyspnœa, giddiness, and coldness. The blood is found to be dull-red in color, and the red corpuscles to be diminished and altered; retinal and other hemorrhage may occur, also occasional attacks of vomiting and diarrhœa. The patient remains, or becomes, fat rather than emaciated, yet the disease has usually ended fatally by exhaustion and collapse in spite of iron and food, etc. Dr. Bramwell has recently recorded a typical case, which was carefully treated

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in hospital for three weeks with full doses of quinine and iron, and later phosphorized cod-liver oil, and yet steadily got worse until 2 min. of liquor arsenicalis were given thrice daily, the other remedies being stopped. The dose was gradually increased to 16 min. thrice daily, and "the after-progress of the case may be described as one of slow but uninterrupted improvement." In a month's time he was able to attend as an out-patient, and continuing to take arsenic considered himself well, and resumed work. His color improved, cardiac murmurs disappeared, and the condition of the blood was found to be normal (*Medical Times*, ii., 1877). Such a case, in conjunction with others, offers much encouragement in the use of the remedy, and serves to illustrate further its alliance with phosphorus, which drug has also proved useful in some similar cases (*v.* p. 55).

Dr. Lockie has lately published illustrations of the value of arsenic as a "blood and cardiac tonic in anæmia" (*British Medical Journal*, ii., 1878). Dr. M. Finney has recently reported three well-marked cases of "pernicious anæmia," two of which recovered under arsenic, and he calls it "one of our surest tonics to the blood-making organs" (*British Medical Journal*, i., 1880). Dr. Withers Moore informs me that in a similar case (idiopathic anæmia), under his care at the Sussex County Hospital, arsenic also proved of service. The patient, a woman, aged thirty-two, showed characteristic symptoms of the malady nine months after a bad confinement, and after frequent epistaxis: she was extremely pale and feeble; the red corpuscles of the blood were few, small, and altered in shape, the white corpuscles not increased in number. For the first three months of her stay in hospital iron was tried in various forms without any benefit whatever; for the last two months she got 3 min. of Fowler's solution thrice daily, and ultimately left convalescent. The case was a typical and severe one, with occasional pyrexial attacks, raising the temperature to 104° F., and even, on one occasion, to 106° F. These attacks were controlled by full doses of quinine, but excepting this arsenic was the only medicinal agent used during the stage of recovery.

Chronic Rheumatism—Chronic Rheumatic Arthritis.—In the condition now designated by the latter term, the value of arsenic has been frequently shown since its recommendation by Haygarth, and the elder Bardsley in Manchester (*Medical Reports*, p. 32). I quite agree with the latter physician in his opinion that the remedy promises well in cases where the vital powers are diminished, and the ends of the bones, the periosteum, capsules, and ligaments are swollen; under the continued use of the drug I have known the joints return to their natural size. Sir R. Christison records a similar experience in cases of "nodosity of joints," and Dr. W. Begbie describes fully the case of a man with swellings of the small joints of hands and feet, very painful, especially at night and in changeable weather, and almost preventing any movement. The pa-

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tient had received no benefit from a long trial of many remedies, but under a course of Fowler's solution recovered the use of the joints, and was able to resume his work. Dr. Fuller speaks highly of the remedy in "chronic rheumatism," and especially in rheumatic arthritis, when the skin is dry and inactive, and the patient chilly.

Snake-bite.—Among blood diseases we may include this form of blood-poisoning, and although it is difficult to credit arsenic with efficacy in such cases, we must admit not only a long tradition in its favor in India (*v.* Dr. Russell's "History of Indian Serpents"), but some amount of clinical evidence. A compound of white arsenic with black pepper and native herbs is the popular form, known as "Tanjore pill," but Mr. Ireland used 2-dr. doses of the liquor arsenicalis with 10 min. of tinct. opii every half-hour for four successive hours in five cases, and all of them recovered, although other patients died from similar bites (*Medico-Chirurgical Transactions*, ii., p. 393). No doubt, the system, under abnormal influences, can tolerate larger doses than in its healthy state.

Diabetes.—Like most other medicines, arsenic has been tried in this malady, and it has received commendation. Dr. B. W. Foster says that he has seen it act well in improving nutrition and lessening thirst, but not in diminishing the excretion of sugar; hence, he considers it acts mainly by saving the waste of albuminous tissues ("Clinical Medicine," p. 208). Dr. Bartholow finds it beneficial in thin subjects with defective assimilating power, but not in the "stout subjects" who suffer from boils and carbuncles. I have frequently prescribed it in both stout and thin subjects, with good results, but as a rule it only acts as a palliative, checking the sudden emaciation and prostration and relieving the excessive thirst and dryness of mouth. In several cases it lessened for a considerable time the quantity of urine, and in some instances appeared to diminish the sugar; it certainly in nearly all cases improved digestion.

Neuralgia.—Arsenic holds a chief place among remedies for neuralgia. Dr. Fowler's original reports contain several conclusive cases, although their relief seems somewhat counterbalanced by the gastric symptoms, which he did not scruple to produce. Maculloch, in a well-known "Treatise on Malaria," speaks highly of arsenic in confirmed neuralgia; and Romberg, a still higher authority, notes its value especially in facial neuralgia, and in forms connected with uterine or ovarian disease. Anæmia is also an indication for its use, and full doses are necessary. Among modern French observers, Isnard reports many cures of various typical neuralgiæ, and of ordinary neuralgic pain ("De l'Arsenic dans la Pathologie du Système Nerveux"). M. Boudin found it invariably succeed in periodic—probably malarial—forms, and M. Cahen has published sixty-five successive cases of almost uniformerly good result (*Archives de Méd.*, 1863). Borella devotes a long chapter of his work in praise of arsenic, to its value in nerve-disorders (Brussels, 1866). Of

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modern German writings on the subject we may quote Erb, who adopts mainly the views of Isnard, considering the remedy as "a neurosthenic tonic," with the power of restoring order to disturbed action. He places it in the first rank among specific remedies, not only in recent and periodic cases, but also in chronic forms of purely idiopathic neuralgia. In the facial variety and in sciatica, he endorses its high reputation, but in the latter affection places its value below that of turpentine ("Ziemssen's Cyclopædia"). In the treatment of sciatica, arsenic is most suitable when the pain is deep-seated, worst at night, but with occasional marked intermissions, and temporarily relieved by hot applications.

Sir Thomas Watson notes the great use of the drug in hemicrania or migraine (Op. cit., i., p. 733), and successful results in various cases from full doses of Fowler's solution were published by Mr. Thomas Turner, of Manchester (*Medical Times*, ii., 1861). Dr. Anstie, in his "Treatise on Neuralgia," speaks of arsenic as "one of the most powerful weapons in the physician's hands," "likely to act best in affections of the fifth and of the vagus nerves, but probably the most generally effective remedy in almost any given case." He looked upon it as calculated to improve the quality of the blood, to stimulate the nerve-system, and oppose periodic (disordered) action. The same physician also pointed out the connection and frequent interdependence of gastralgia, angina pectoris, and asthma, as neuroses of different branches of the vagus, and he illustrated this connection by the history of families in which these affections occurred in alternate generations. From my own extensive trial of arsenical medication in neuralgiæ, and especially of the fifth pair of nerves, I also conclude it to be almost our best remedy, particularly, as in my own person, when the pain felt is of burning stinging character, and when the attack is connected with miasmatic influence.

Gastralgia is a term properly restricted to painful affections of the stomach unconnected with organic disease or inflammation, or even with ordinary dyspepsia. Such cases are not very frequent nor very easy of diagnosis, but occur especially in females during youth, and at the climacteric period, and are accompanied with other evidences of impaired nerve-power: sometimes they are reflex (being connected with uterine derangement), and sometime malarial (Niemeyer). Trousseau describes attacks dependent on exhaustion, and Budd on alcoholism. The nerve-character is evident when, as in Dr. Anstie's cases, the malady alternates with attacks of asthma, and Tessier (*Journal de Méd. de Lyon*, 1848) and Anstie agree in estimating highly the value of arsenic in such cases. Dr. Clifford Allbutt speaks of gastralgia as readily distinguishable from dyspepsia, and described sudden violent pain in the gastric region and back, and another form less severe and more gradual in onset, and irregular as to time, and unconnected with eating (*Liverpool and Manchester Reports*, 1873). Dr. Leared also restricts the term to a nerve-disorder with cramp-

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like, fixed or diffused pain, coming at irregular intervals, often at night, accompanied by prostration, followed by bilious vomiting, and occurring generally in middle-aged persons from mental anxiety (*British Medical Journal*, 1867). Such cases furnish a special indication for arsenic, and Allbutt says it is, for such, the "king of remedies," only I would interpret "gastralgia" in a wider sense, and without attempting to diagnose it rigorously from dyspepsia, would include under the term many forms of painful stomach-disorder, not inflammatory nor organic. In this sense it is used by Barras ("Traité sur les Gastralgies") and other French writers, and a reference to the observers I have named will show that, in their cases, such symptoms as flatulence, vomiting, and pain increased by food, were often present, and although the tongue might be clean, and certain dyspeptic symptoms absent for a time, yet they would readily occur, and to restrict the use of the remedy to purely nervous attacks is needlessly to limit its value: we shall see, in fact, that in gastric catarrh it is an excellent medicine.

The following is one of many cases of climacteric gastralgia, complicated with dyspepsia at times, and relieved by arsenic. Mrs. S., aged forty-three, auburn hair, thin, describes very acute pain in upper front chest, and sometimes in the back about the second dorsal vertebra and interscapular region, almost constant; sometimes easier after food, sometimes worse: no vomiting, pyrosis, or hæmatemesis: no physical signs in the chest, no evident hepatic disease, and bowels regular. Pulse 64. No heart or lung complication. Youngest child is five years old. Menstruation lately irregular and profuse; has some prolapsus and back-pain, distinct from her gastric pain. Nursed her husband anxiously for two years, during which time the pain first came on, and is now often brought on and always aggravated by mental worry, of which she has much. The pain is generally worst on waking, about 2 A.M.; gets better after breakfast, and worse again in the evening: it is sometimes referred to the epigastrium and left shoulder, and described as "like a hot bar pressing," or "like a hand gripping." Arsenic relieved the pain more effectively than any other remedy tried, and although during attacks of painful digestion nux vomica given before food did much good, according to the patient's own statement, the steady use of arsenical solution was always the most effective.

Angina Pectoris.—This malady, even if primarily dependent on calcareous or other degeneration, is mainly a neurosis, and nearly 100 years ago was successfully treated with arsenious acid by Alexander. Philipp and others record very striking benefit in cases that had been rebellious to quinine (*Sydenham Society's Year Book*, 1865–66), and I can fully bear out Dr. Anstie's testimony to the great relief given by arsenic to patients suddenly attacked with spasmodic pain, embarrassed heart-action, and sense of impending death: he found the medicine reduce the severe

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attacks to little more than a tightness of the chest, and it availed most in anæmic patients, suffering from overwork and anxiety. (Reference may also be made to cases in *Berlin. Klin. Woch.*, 1865, and *Archives Gén.*, 1863.)

Spasmodic Asthma—Asthma Nervosum.—In this, the third of the trio of vagus neuroses, Dr. Anstie also records good results, but others had preceded him in this observation. We have already noted its improving the breathing-power of mountaineers, and this had suggested to Kappel its use in asthma. Rilliet speaks highly of it (*Bulletin Med. du Nord*, 1863), and also Trousseau, who used it partly in cigarette (*Bulletin*, 1861). Dr. Leared recommends a form of cigarette containing ½ gr. of arsenic with a little nitre (*Lancet*, i., 1863). Dr. Thorowgood, while laying stress on the frequent gastric causation of asthma, and its special treatment, has found arsenic useful in gouty and rheumatic cases, and Riegel notes its value in preventing relapses in "bronchial asthma," and in the form which occurs alternately with some cutaneous diseases, known as "herpetic asthma" ("Ziemssen's Cyclopædia," iv., p. 582). Dr. Berkart seems to attribute any good effect more to improving the nutrition, appetite, and digestion, and to negative any specific virtues ("On Asthma," 1879). One method of its application is by spray, which has been used with much success by Wistinghausen (*Petersburg Med. Zeits.*, 1862), and more recently by Dr. Wahltuch, of Manchester: the latter used arseniates of potash, soda, or ammonia in spray containing $\frac{1}{8}$ to ½ gr. at first twice daily, and by degrees less frequently; his excellent results were, however, rendered less certain for clinical purposes by the concurrent use of galvanism and other remedies (*British Medical Journal*, ii., 1877).

Martelli has recently reported immediate relief to an asthmatic paroxysm from the hypodermic injection of Fowler's solution (1 part to 2 of water): the cure was complete after 2 dr. used at intervals in divided doses in this manner (*Medical Record*, 1878). Arsenic acts best in simple cases of idiopathic or spasmodic asthma of neurotic origin: but it has done well in cases dependent on bronchitis, emphysema, or cardiac disease. In cases due to compression of air-tubes by enlarged glands it may be carefully tried (Berkart). The solution should be administered in 5-min. doses, three or four times daily, during the intervals between the attacks, and should be persevered with for many weeks, and, in some instances, for months, but the dose under these circumstances should be decreased. For upward of twenty years I have used it in these cases with unmistakable success.

Chorea.—From the time of Girdlestone, 1806—(*London Medical and Physiological Journal*), there has been a large accumulation of evidence as to the value of arsenic in chorea. Reese, of New York, in 1840, describes cures in two hundred children under 6 to 8-min. doses of Fowler's solution twice daily. Rayer corroborates his results (*Union Médicale*, 1847).

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Romberg calls it "the foremost remedy," when given in sufficient doses (*Klin. Ergebnisse*, 1856), and records severe cases—one of eight years' duration, rebellious to many other medicines, but cured in two months by arsenic; and another patient had been unable for six months to stand or speak, having such violent choreic movements, yet recovered after two months of treatment with 4 min. of Fowler's solution thrice daily. The well-known names of Aran, Henoch, Steiner, and Barthez may also be cited as authorities in the same direction; and continental work with regard to it is fully summarized in the thesis of M. Gellé ("Hôpital des Enfants," Paris, 1860). He quotes cases where improvement was manifest within eight days, three days, and even forty-eight and thirty-six hours respectively, but concludes that from five to eight days is an average period. He gives also several cases equal in severity to those of Romberg, and expresses similar conclusions—viz.: that some failures of the remedy may be expected in neurotic, sanguineous subjects, but very great success in the lymphatic, chlorotic, and cachectic. M. Aran urges the rapid attainment of a full dose rather than a long-continued small one (*Sydenham Society's Year Book*, 1859). Dr. Steiner, on the other hand, commences with 1 min., and considers 8 min. should be the maximum daily dose: within fourteen days he expects improvement.

Among English observers there is a large preponderance, though by no means a consensus of opinion in favor of arsenic as the best remedy for chorea. Gregory, Babington, and many others have all written to this effect. Dr. Radcliffe fully agrees as to the efficacy of the medicine, but, having been obliged sometimes to discontinue it on account of gastric disturbance, he adopted its hypodermic use, and in some cases, especially of localized choreic action, with signal benefit; thus, in a woman in whom the neck-muscles were affected, and who was not relieved by a long trial of sedatives, 1 to 12 min. of Fowler's solution were injected locally, and, before the fourth injection, improvement had taken place. He recommends dilution with half water; in some cases he has preferred the endermic use of the remedy on a blistered surface ("Reynold's System," vol. ii.). Schmidt has also practised hypodermic injection with success (*Wiener Med. Woch.*, 1871, No. 44). Dr. Anstie records the severe case of a girl who had been treated in hospital with camphor, cod-liver oil, bromides, and zinc, also with succus conii in the dose of many ounces daily, yet without relief, and who recovered under 3 to 5-min. doses of Fowler's solution: he used at the same time ether spray to the spine, but this application has not proved itself of such power as he then thought it (*Practitioner*, June, 1874), and therefore I do not believe that it much influenced the result. Dr. Ringer considers arsenic as by far the best remedy in simple chorea; he remarks that failure may be owing to smallness of dose; also that children above five years of age bear nearly as much as adults, and that girls seem to require more than boys. Dr.

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Eustace Smith and others have also specially noted the tolerance of choreic children for arsenic, and the necessity of full doses to secure success (*British Medical Journal*, i., 1875). In my own practice, for upward of twenty-five years, I have seldom known arsenic fail to cure simple chorea, although many of my cases were severe and of long duration, and quite incapacitated for the ordinary duties of life—3 to 10 min. of Fowler's solution thrice daily has been the dose usually prescribed by me, but I have frequently observed no permanent good effects follow until the development of some of the slighter physiological symptoms.

From the above quotations and remarks, though they represent an ample experience, we must not conclude that the value of this remedy is equally acknowledged by all. The counter-claims of iron, of zinc, of belladonna, etc., are urged by some observers, and the natural tendency to cure of the malady under favorable conditions is still more strongly insisted upon by others. Vogel, the distinguished Russian professor, classes arsenic with "a number of empirical remedies that are more praised than curative." Dr. Wilks attributes much more importance to rest (*British Medical Journal*, ii., 1876), and my colleague, Dr. Sturges, includes arsenic among a number of other "useless medicines" ("Lectures on Chorea," 1876). In estimating the value of any remedy, we are constantly met by the difficulty of proving how far we have affected the course of nature; this difficulty is not greater with the present medicine than with others, and even allowing that chorea will recover with proper rest, food, and management, yet I am clearly of opinion that arsenic will promote, and quicken, and confirm the cure. I cannot affirm that it will always, of itself, and in despite of circumstances, control the disease. Judging from private practice and from hospital in-patient records, a large number of cases recover while taking arsenic, either far more quickly than is consistent with the ordinary course of the malady, or (making the contrast more striking) recover after many powerful remedies have been tried without effect under equal conditions. The ordinary duration of a chorea well managed, but without medicines, has been stated as six to eight weeks; if it continues three months Jaccoud considers it chronic, almost incurable, yet we have already quoted and have seen many cases that improved within two or three days, and recovered within three to five weeks, and we have quoted also cases of cure after a duration of many years. A certain proportion of cases of chorea are connected with embolism, and these were excluded by Dr. Anstie from the range of the beneficial action of this drug, but from what we know of its value in cerebral congestions, we should think it often appropriate even in such serious conditions. In markedly anæmic patients we might prefer iron, or at least combine it; and if sexual excitation were present, as in the case of some girls at puberty, we might substitute bromides or antispasmodics; acute rheumatic symptoms would also modify the treat-

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ment, but with these exceptions we must consider arsenic a most valuable agent in all varieties of the malady.

Tremor—Ataxia.—Allied to the use of arsenic in chorea, is its use (which, however, is much less markedly beneficial) in these nerve-conditions. Tremor may be due to various causes, which are often central and connected with organic disease, and scarcely amenable to treatment; but Eulenburg reports several cases successfully treated by hypodermic injection of 2 to 3 min. of Fowler's solution diluted with two parts of water (*Berlin. Klin. Woch.*, 1872, No. 46). Isnard says the remedy is valuable in ataxia developed during acute fevers; he gives it even during febrile accessions.

Congestive Disorders.—The value of arsenic in the following group of cases seems best explained by its power, in small doses, to regulate and equalize the circulation in capillary blood-vessels.

Cerebral Congestion.—As a preventive of apoplexy, the remedy has a traditional, and perhaps not an easily proved, reputation, but one that would be quite in accord with our view of its action. Lemare-Piquot, after relating marked relief to giddiness, sense of oppression, epistaxis, and other premonitory symptoms, both in his own case and that of five other persons about sixty years of age, reasonably restricts its use to cases of cerebral congestion occurring in the strong and plethoric, who have an excess of blood-corpuscles (*v.* p. 33). He recommends from 4 milligr. to 1 ctgr. daily for about a month, taken at meal-times, and founds his latest conclusion upon forty-four cases occurring without one death (*Bulletin de Thérapeutique*, 1859, and *Recherches sur l'Apoplexie*, Paris, 1860). Cahen, writing upon its value in congestions generally, and cerebral hyperæmia in particular, traces it, as we do, to a regulating influence on vaso-motor nerves (*Archives de Méd.*, September, 1863), and Dr. Handfield Jones expresses similar views. Hirtz has had reason to think it efficacious in obviating apoplexy, and suggests that it would tend to prevent atheromatous degeneration ("Nouveau Dict."). It is extremely useful in cerebral congestion, and especially when there is puffiness below the eyes, drowsiness, and mental torpor, with sluggish, venous circulation, and suspicion of commencing atheroma. By a similar action, perhaps, it benefits the melancholy and those suffering from hypochondriasis, especially aged persons.

Epilepsy has been plausibly connected with congestion in and near the medulla oblongata, and certainly the older writers, such as Alexander and Duncan, have recorded cases cured under arsenical treatment. It is of necessity no more a universal cure than any other medicine is, but there seem to be some cases specially amenable to it—for instance, those that are connected, however remotely, with malaria. We must note a case recorded under the supervision of Dr. Bristowe, that of a lad of fourteen, described as anæmic, but free from evident organic disease, and

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who had suffered severely from epileptic attacks, mainly nocturnal, for about two years, and afterward from attacks, day and night, so frequently that he remained unconscious for some days, and was apparently dying; being roused, however, from this condition, he remained partly paraplegic, and the fits, preceded by screaming and by an aura in the feet, recurred on movement of the legs, or on excitement; for nearly a month he took zinc sulphate in increasing doses with valerian, but remained in the same state, sometimes disturbing the ward for a whole night; he was then ordered 5-min. doses of Fowler's solution thrice daily, and although he was not made aware of any change in treatment, the attacks ceased at once for many days; they recurred for a time under excitement, and the numbness of lower limbs persisted for some days; eventually, however, he got quite well. There is evidently some alliance between such a case and cases of chorea, but the periods of insensibility indicate a more serious condition; the exact character of the "fits" is not, however, described (*Medical Times*, i., 1862).

Dr. Clemens (Frankfort) strongly recommends a "liquor arsenici bromidi," which he has used for twenty years in the treatment of epilepsy of all varieties with much success; it has relieved even in cases connected with thickening of skull and congenital malformation (*Medical Record*, 1877). This preparation is said to be more reliable than Fowler's, and to act well without increase of the daily dose: it is made by boiling potash carbonate and arsenious acid, of each 1 dr. in ½ pint of water: making up to 12 oz., adding 2 dr. of bromine, and mixing thoroughly.

Cardiac Weakness—Mitral Disease—Venous Congestion.—For such conditions, arsenic is often found serviceable, and under its use dyspnœa on exertion, the palpitation, the faintness, and the œdema of extremities have all improved. Dr. Papillaud has verified similar improvement, and also marked relief to palpitation, but he generally alternated or combined the remedy with antimony (*Bulletin de l'Academie de Méd.*, December, 1870, p. 885).

When *intermittent pulse* occurs from cardiac weakness, whether of temporary character or dependent on degeneration or mitral disease, arsenic is often serviceable, as it is also in the same condition when due to nerve-causes. Darwin relates a case of "regular intermission" cured by 4-min. doses of a saturated solution of the drug (Headland, p. 197). I have seen numerous cases cured by the continued use of 2 to 5-min. doses of Fowler's solution after each principal meal. Under such circumstances it often produces a marked diuretic action, which is quickly followed, in many instances, by disappearance of any swelling, and by relief of the dyspnœa, faintness, and palpitation.

Albuminuria.—The influence of arsenic upon this condition is well worthy of further investigation. A case of "acute renal anasarca" in a woman, aged nineteen, is briefly recorded from Dr. F. Farre's practice

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(*Lancet*, i., 1862); six weeks after the commencement of the attack she developed psoriasis, for which Fowler's solution was prescribed, and under its influence the albumen disappeared, and the patient gained flesh and strength. I have for many years used it in albuminuria following scarlatina; it removes the dry inactive condition of the skin, checks thirst, and causes a copious flow of urine, which gradually becomes less loaded with albumen; should dyspnœa be present, the remedy quickly relieves it, and the œdema of face and body disappears. In 1876 a case came under my care of chronic character, occurring in a builder, aged forty-three, of dissipated though hard-working habits; he had general anasarca and epileptiform convulsions, which were relieved for a time by laxatives, but the amount of albumen was uninfluenced by them, or by a long-continued use of iron. Fowler's solution was substituted, and the albumen diminished and soon ceased to appear; then, omitting the medicine, a relapse occurred; this again yielded on resuming the remedy, and the albumen, anasarca, and convulsions all disappeared, and in two to three months the patient's health was quite re-established, and he has since been quite well. I have also treated by liquor arsenicalis, with excellent results, numerous cases of *temporary or intermittent albuminous urine* dependent on imperfect digestion.

Dr. Brunton has discussed this subject in an interesting and scientific paper (*Practitioner*, June, 1877): he remarks on the important distinction between "true and false" albuminuria (Gubler), including under the latter term, not only the presence of albumen from pus or blood, but also the so-called Bence Jones' albumen, egg-albumen, the albumen absorbed from the intestine after imperfect digestion: it is a case of the latter kind that is recorded by him as being much benefited by arsenic, and it had several peculiarities. The patient was aged thirty-three, sallow and thin; the first symptom was great fatigue on exertion, then albuminuria was noticed (on examination for life insurance): it was at first present only during the summer; it came on after work and ceased on rest; it ceased also under strychnine (but this caused headache and sickness), and it ceased during quiet residence at the seaside. Fatty food brought it on, and meat taken in the morning, not when taken at night. Quinine and phosphoric acid at once increased the quantity, but rigid adherence to a farinaceous diet quite controlled it, and there were other evidences of its direct connection with digestion. After many years of treatment, including milk-diet, sea-voyages, digitalis, hydrarg. c. creta, etc., Dr. Brunton ordered 3 min. of Fowler's solution at meal-times, "and almost at once the albumen disappeared, and the patient was able to do much more work than usual, without its return." Later, the medicine was changed for hypophosphite of soda, and the albumen returned, to cease again on resuming arsenic. The whole case is very interesting, but we need only mention further that pancreatine, which increases pan-

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creatic digestion and aids in the solution of albumen, was also found beneficial. This affection should be classed under faulty digestion or assimilation rather than as renal disorder. The special form of chronic albuminuria in which I have proved its value is that dependent upon venous congestion, mitral disease, or emphysema, after the right ventricle has begun to yield, but it deserves a trial also in cases where the actual kidney structure and epithelial lining are affected. I have carefully watched many of these latter cases in which the beneficial action of arsenic was very marked.

Uterine Congestion.—This condition may accompany either menorrhagia or amenorrhœa, and that arsenic may remedy either symptom is, therefore, not contradictory. In the former, the catamenia being too copious and too frequent (leucorrhœa often occurring in the intervals), and the patient becoming weak and anæmic, small doses of from 2 to 6 min. thrice daily will be found to lessen the flow and to improve appetite and general health. Mr. Hunt has recorded some striking cases of uterine hemorrhage at various intervals after labor or miscarriage, some accompanied with symptoms only of irritable uterus, "but for the most part atonic in character" (*Medico-Chirurgical Transactions*, vol. xxi.); all improved under arsenic. Sir C. Locock found great advantage from it in similar cases. Dr. A. Burns, from experience of it in all varieties of uterine hemorrhage, has reason to express the greatest confidence in the remedy, and records several cases treated by rather large doses, 10 to 20 min. repeated every fifteen to twenty minutes (*American Journal Medical Sciences*, October, 1859).

Amenorrhœa.—When this depends upon congestion or torpor of the uterus, or is connected with anæmia or chlorosis, I have known arsenic succeed well, and have several times found that when iron preparations had been taken without marked result, the addition of arsenic was quickly followed by relief—it seemed to act as a regulator of the circulation and as an uterine tonic.

Hemorrhoids.—The efficacy of arsenic in this form of venous congestion has been sometimes well shown; thus, in one case, a gentleman had suffered for many years, and had undergone cauterizing and other operations, when this remedy was given to him for hay-asthma, and he found his hemorrhoids to be more relieved in a few days than under any other treatment. Relapses occurred more than once, but always yielded in a few days to 8-min. doses of Fowler's solution (Parvin, in *Braithwaite's Retrospect*, ii., 1866). I can recommend it strongly in painful hemorrhoids, and also for ordinary external piles.

Cutaneous Disease.—Arsenic is largely used by the profession, almost as a routine remedy, in cutaneous disease, but its value has been variously estimated by specialists of experience. We may exclude at once from its influence the ordinary acute exanthemata, also nævus, parasitic and syph-

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ilitic eruptions, and the rarer maladies of scleroderma, keloid, xanthelasma, and true leprosy. We may exclude also all forms of skin disease while in the *acute* stage, or while accompanied by marked inflammatory reaction, and then, speaking generally, we may say that as we have noted arsenic to be valuable in rheumatic, malarial, and neurotic affections, so is it also valuable in most cutaneous manifestations of these conditions. With regard to the last-mentioned, my own experience agrees rather with that of Hunt and of Anstie, as against Bazin and others, that in neurotic subjects with highly strung excitable natures, arsenic is less readily borne, and more usually causes diarrhœa.

The forms of skin disease in which the remedy is of generally accepted value, are such as psoriasis, eczema in the dry or scaling stage, pemphigus, lichen, alopecia, and chronic urticaria; and those in which its powers are more controverted are acne, lupus, ichthyosis, herpes zoster,[1] sycosis, prurigo, epithelioma, cancer, and elephantiasis græcorum.

Psoriasis.—From the time of Girdlestone (1806), Willan and Bateman, Biett and Cazenave, arsenic has held the first place in the treatment of this malady. Modern dermatologists agree upon this point, but some, as the late Mr. Startin and Mr. Hunt, rely upon this drug much more positively than others. The preference of Hebra for local over any constitutional treatment is well known, but even he recognizes "a decided curative action of arsenic in this form of disease." Dr. Tilbury Fox inclines to restrict its use to the more typical cases, especially those of chronic character and accompanied with nerve-debility; on the other hand, many cases will be found to occur in persons otherwise strong, and in such cases after preliminary purgative treatment I have found the remedy useful. "Before undertaking to deal with psoriasis," remarks Gaskoin, "it is necessary to know all about arsenic" ("Treatise on Psoriasis"). Its success, however, is, as Stillé remarks, by no means uniform, and any want of due attention to the excretions, to the presence of gouty or other constitutional tendencies, or to the proper regulation of dose, will readily prevent a satisfactory result. It can by no means be considered a specific, but as a valuable agent only under certain conditions; neither can it be accurately stated that "the more chronic the malady the more suited it is for this remedy," for after it has lasted for eight or ten years I have seldom found it amenable, and Devergie has recorded a similar experience ("Maladies de la Peau").

Mr. Malcolm Morris notes that sometimes arsenic not only does no good in psoriasis, but harm, in rendering the patches more hyperæmic and irritable; he finds it impossible, however, to diagnose the cases in which this may occur (*Practitioner*, 1880).

[1] The reason for doubting the value of arsenic in herpes is that it is a disorder of definite course, which must develop, but the neuralgic pain, if severe, *is* markedly lessened by arsenic (*v.* p. 67).

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In judging of its true power, we must allow for the natural improvement of the malady in certain circumstances, *e.g.*, on the cessation of lactation, at changes of climate or of season, etc., also for the effect of external treatment by tar or bathing carried on at the same time. But after these allowances there remain, no doubt, many cases which show improvement distinctly from arsenic; the best illustrations are seen in children, and then in older persons in whom the attack is comparatively recent yet not in an acute stage; chronic cases that have been left untreated often do well, but previous irregular trials diminish the chances of recovery. In any case, if cure be effected, freedom from relapse cannot be guaranteed (Wilson); Hunt has shown how important it is to secure a due action of the absorbents, and also that one preparation may succeed when another has failed; for instance, to one of two girls similarly affected, he gave the potash, and to the other the soda solution; for a time both did well, and then both ceased to improve, but later on, when he exchanged their medicines, they progressed to cure (*Journal of Cutaneous Medicine*).

Eczema.—In this, which is a catarrhal form of disease, arsenic has not so large a measure of success as in the last mentioned; still it is often very useful, and especially in combination with other remedies. Acute cases not only receive no benefit, but I have seen them much aggravated by it; the proper period for its use requires, therefore, careful consideration. It is very suitable in scaly—which are of necessity rather chronic stages, and have received the distinct name of "eczema squamosum"—in superficial subacute forms with moderate infiltration, and in cases with persistent irregular patches about the scrotum, anus, or vulva (Rayer), or about the hands or fingers (Duhring). Sometimes the later stages of a chronic infantile eczema seem much benefited by the addition of the drug to iron or cod-liver oil, and sometimes an infant has been successfully treated by arsenical medication through the mother (Begbie, Anderson). The last-named observer, in his excellent special treatise, estimates the value of arsenic highly: he points out, as others have done, that children will readily bear a proportionately large dose; at the same time, he notes that there is much tendency to "catching cold," or even bronchitis, during an arsenical course, also he insists on the necessity for its prolonged continuance. Mr. Erasmus Wilson considers that the treatment of eczema resolves itself into that of "debility," and advocates the use of arsenic "as a nerve-tonic and stimulant to cutaneous function;" and generally combines it with a non-astringent preparation of iron, as the vinum. My own use of arsenic in ordinary eczema is rather the exception than the rule, and I am much in accord with Dr. Piffard, who, after calling this mode of treatment "empirical, as opposed to rational," and quoting the prevalent opinion, "that if only sufficient of the remedy be used, the eruption must yield," states that, in his experience, it sometimes does

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harm and at other times has no influence, though in a minority of cases will give brilliant results: these may be hoped for in the dry scaly stages when extensive tracts of surface are affected ("On Skin Diseases," 1870); I would add, and when there are persistent patches on the pudenda or extremities, as already described.

Pemphigus.—There is an ephemeral form of this malady in which one or two crops of bullæ come out, and subside under mild general treatment; there is also a syphilitic form, mainly congenital, and an epidemic form which occurs sometimes in lying-in and in children's hospitals, and is connected probably with blood-poisoning; in none of these do we expect benefit from arsenic. There is a fourth form, occurring sometimes in the later months of pregnancy, which may be severe, and although it tends to subside after parturition, yet may receive some benefit from the remedy; but the variety of the malady to which we would specially refer is that known as "pemphigus diutinus, in which the blebs come out freely, often symmetrically, and extensively—which often lasts long, and almost invariably exhibits its constitutional origin in a marked tendency to recur." Mr. Hutchinson, from whom I quote, has certainly furnished us with valuable evidence of the great power of arsenic in this variety, and although by Hebra and others it is commonly held to be incurable, and often fatal, Mr. Hutchinson "has never met but with one case that resisted this treatment, and has come to consider the malady as one of the most hopeful" (*Medical Times*, ii., 1875). He furnishes an abstract of twenty-six cases that have been under his own observation, and refers to others in the practice of Hillier, Wilks, Fagge, Startin, etc.: many of them had relapses, but these were mild in character. In many, the influence of the medicine was proved by the rapid improvement, and by relapse, on resumption and omission of it respectively, and in at least one case it appeared to prevent a patient's death. A delicate man, aged forty-four, recently become subject to epileptic attacks, presented a general rash, at first very like herpes, and attacking the face and extremities. There was much prostration, and the patient was treated with quinine and iron, and liberal diet, yet became extremely emaciated, and as the pemphigus character became more developed, he was covered with large superficial sores and completely prostrated; then the tonics were stopped, and 4 min. of Fowler's solution prescribed, and from that day no fresh blebs appeared until a few weeks later when nearly well and able to leave his bed: it was then found that his medicine had been omitted for three days, and on resuming it, the blebs at once receded, and six weeks afterward he was in good health and wholly free from eruption (Op. cit., p. 625). Dr. James Russell has also published a well-marked case in a child in whom the numerous relapses were always distinctly controlled by arsenic (*Medical Times*). On the other hand must be noted the observations of the late Dr. Tilbury Fox: "There is no specific for pemphigus; arsenic is

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declared to be one, but it often signally fails to cure the disease, and I have seen quinine, in full doses, do much more good."

In *Lichen Simplex*, and certainly in its more chronic forms, the value of arsenic is generally conceded. Dr. Liveing's expression is, "In chronic lichen it is the only remedy;" but, as a rule, alkalies are required in addition, and mercurial treatment may succeed still better. A similar observation would apply to another form of papular disease—true prurigo.

In *Lichen Planus*, Mr. Morris (loc. cit.) and others speaks well of it. Thus, a lady, aged fifty, with an itching eruption of flat-topped violet-colored papules, slightly scaly, situated on the inner side of the thighs and outer sides of forearms, took 8 min. of liquor sodæ arseniatis, at first twice and then three times daily, and the eruption faded in one month, and the treatment being continued for a time, no relapse occurred (how long the eruption had lasted is not stated). He considers arsenic "an invaluable remedy." Dr. Fox has, however, seen no benefit from it.

In the more generalized form of the malady, Hebra, who names it "lichen ruber," places much reliance on the "Tanjore pills" (arsenic with black pepper).

Alopecia.—From the effect of arsenic in improving the coat of horses, it has been plausibly thought to have a special power in promoting hair-growth, and certainly after any sources of baldness, such as syphilis, dyspepsia, or local irritation, have been treated and removed, the internal administration of small doses may be carefully carried out for a time with advantage. Hunt practised this treatment successfully.

Chronic Urticaria is often relieved under arsenic, but any evident intestinal disorder should, if possible, be remedied in the first instance.

Acne.—In acne it should be the exception to prescribe arsenic. Mr. E. Wilson goes so far as to say that "no one having even a rudimentary acquaintance with cutaneous pathology and therapeutics would think of doing so," and yet I have certainly seen cases cured by this remedy after others had failed. According to Dr. Bulkley, this has occurred with all forms of acne—the simple, the indurated, and the rosaceous—and his best results have been attained with De Valangin's solution of chloride. Dr. Duhring speaks well of it in the indolent papular form, and many special authorities might be quoted to the same effect. This does not seem to me so unreasonable as it does to Mr. Wilson, for acne is frequently connected with gastric and uterine irritation, and we have seen that arsenic has great power to relieve various forms of this malady.

In "bromic acne"—the pustular rash which frequently follows the use of full doses of any bromide—arsenic is decidedly useful. If given concurrently with the bromide it will often prevent any skin trouble (Bartholow; also Gowers, *Lancet*, i., 1878), and I can corroborate this observation.

Lupus.—There are differences of opinion as to its value in lupus: Mr.

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Hunt, for instance, and Mr. Milton esteeming it highly, and recommending its continuous administration for months or years; but others, and, indeed, the majority of observers, recording no definite result from it. I have never been able to satisfy myself that it controlled the disease, although the local caustic effect is, as already mentioned, highly valuable.

Ichthyosis is congenital, and, though it may be relieved, is scarcely curable; the evidence as to the value of arsenic in its treatment is but slight.

Herpes Zoster.—Trousseau has observed that the pain in the course of affected nerves, which is often severe and long persistent in the zoster of elderly persons, may be relieved by arsenical medication, though this will not cut short the course of the attack itself ("Clinical Medicine").

In *Sycosis*, non-parasitic in character, there is much evidence of the value of the drug, and this would accord with what we know of it in other cases of pus-formation. Dr. Laycock has used an arsenicated glycerin (2 dr. of Fowler's solution in 10 dr.) as a local application, with good results; it is somewhat strong, and acts as a "substitutive irritant" (*Medical Times*, ii., 1864).

Erysipelatous Inflammation of a phlegmonous type is liable to give rise to sloughing, but if, at the first appearance of this change, small doses of arsenic be administered, together with a generous diet, the more severe results may be warded off, and even after sloughing has taken place, arsenic will often control it effectually.

In *Hospital Gangrene* the results obtained strongly incline me to consider it very beneficial. In twelve cases in which I have tried it, giving 4 to 10 min. of Fowler's solution every two or four hours, I was well satisfied with the result, especially as arsenic was the only active treatment used; no local caustics were needed. In various other affections of gangrenous character the same remedy has proved very reliable.

The so-called "cancrum oris" and ulcerations about the tongue often receive benefit from the same treatment.

Epithelioma, etc.—Cases of this disease affecting the lip, the tongue, the scrotum (chimney-sweep's cancer), etc., are stated to have been cured by its internal administration; and although Hirtz concludes that all reports of true cancer being cured by arsenic internally are founded on mala fides, or bad diagnosis, yet there is some trustworthy evidence of its relieving cancerous pain in the stomach and in the uterus. Sir C. Locock mentions his own confidence in it, together with cases from his practice, and from that of Brodie and Sir A. Cooper (*Lancet*, 1837), and Mr. Hunt records a marked instance of relief under small doses frequently repeated, not amounting to more than 10 min. in twenty-four hours. The case was said to be undoubted uterine cancer, and the relief given was greater than from morphia: as a rule, a pill was preferred, containing $\frac{1}{10}$ gr. or

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less. Fordyce Barker also speaks highly of its power to relieve pain and improve the general condition, in doses of about 3 min. of Fowler's solution (*American Journal of Obstetrics*, November, 1870). Dr. Walshe has written specially to recommend the iodide of arsenic as most valuable (*Dublin Quarterly Journal*, August, 1857, v., p. 9). I have given Fowler's solution internally in many cases of epithelioma, when the disease was extending rapidly, and have known it apparently retard for a considerable time the progress of the malady, relieve the pain, and improve the general condition. Cases where the lower lip or the scrotum was affected have given me the best results: the dose usually prescribed was 5 min. thrice daily.

Elephantiasis Græcorum (*Leprosy*).—Dr. Waring says that for this almost incurable disease arsenic is still highly esteemed in India, and Dr. Benet (formerly of Lahore) records benefit from the Tanjore pill (*Gazette des Hôpitaux*, December, 1842). The external application of arsenious acid is also reported to have cured (*Dublin Medical Press*, 1864), but this must be exceptional.

Disorders of Mucous Membranes.—Without implying that the following maladies are *solely* disorders of mucous membranes, it will be found convenient to group them under this heading. The value of arsenic in them is very marked, but is of comparatively recent recognition, and has not yet been noticed in many text-books.

Coryza—Bronchial Catarrh—Hay Asthma.—In these disorders, in which a profuse secretion is connected with local irritation, and with generally depressed nerve-power, Fowler's solution is often effectual, and it is especially so in patients subject to paroxysmal sneezing, with much itching about the alæ nasi. Dr. Mackenzie had previously reported satisfactory cases of catarrh treated by doses of 3 min. and upward (*London Medical Journal*, July, 1851).

Chronic Bronchitis.—I have witnessed marked improvement under the continued internal arsenical treatment of chronic bronchitis, for which cigarettes and inhalations are sometimes even more suitable than ordinary doses. Bretonneau and Trousseau have recorded good results, and the latter devised a simple cigarette, made with suitable paper, soaked in solution of arseniate of soda, or of potash (1 to 4 gr. in 20 gr. of water for twenty cigarettes). Four or five mouthfuls are inhaled several times daily; more often when the patient becomes accustomed to it. M. Papillaud recommends, in chronic bronchitis and emphysema, a combination of the drug with antimony (an arseniate of antimony), and considering the relations between these two substances, the recommendation is likely to prove very good (*Gazette de Paris*, 1865, No. 43, etc.).

Dyspepsia.—In many cases even of irritative dyspepsia, when the tongue is furred, with red edges and tips, and there is pain after food and heartburn, and tendency to diarrhœa after eating, I have had ample

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experience of the value of Fowler's solution given in 2 or 3-min. doses after meals. Dr. Thorowgood finds that it acts best when the attack seems localized in the stomach, and is independent, *e.g.*, of hepatic congestion (*Practitioner*, 1870). Dr. Anstie, whose first published observations were directed to the value of arsenic in gastralgia, previously mentioned to me its equal efficacy in the dyspeptic conditions described.

Vomiting—Diarrhœa.—In chronic forms of vomiting connected with ordinary dyspepsia, and in that of alcoholism which occurs usually in the early morning, and is of a bilious character, with painful straining, arsenic is often useful: also in the retching and vomiting of pregnancy I have obtained excellent results from 2 to 5-min. doses. Dr. Décamp has highly recommended the same treatment (*Philadelphia Medical and Surgical Reporter*, 1872, No. 27), and Bartholow mentions, as additional indications for it, the rejection of the food, *streaked with blood*, or blood only, also gastralgia and interscapular pain. It is not only serviceable in cases of the rapid passage of half-digested food occurring very soon after meals, but also in cases where the motions are frequent, watery, containing mucus, offensive and irritating to the anus, and even when bloody and dysenteric in character and accompanied with tenesmus, prostration, and vomiting. In true dysentery, especially when of malarial origin, and verging into a chronic state, arsenic is often of the greatest value.

Chronic Gastric Catarrh.—In cases of this malady marked by oppression and discomfort after eating, with a sense of weakness and emptiness at the stomach, thirst, offensive breath, coated and red-edged tongue, flatulence and pyrosis, with rejection of glairy acid fluid, and general symptoms of depression, coldness of extremities, and emaciation, I have had ample experience of the good effect of small doses. In acute gastric catarrh also, I have not been often disappointed, though a more cautious use is needed, but in the chronic forms, especially when coexisting with emphysema, with chronic bronchitis, or with phthisis, arsenic always gives some relief. Germain speaks favorably of the treatment (*Gazette Hebdomadaire*, 1860), and Trousseau remarks that the evidence in its favor is such as to warrant a fair trial of it. Many mineral waters that have a reputation in chronic gastric maladies contain an appreciable quantity of arsenic, notably those of Mont Dore, Plombières, and Bussang. Dr. Wilson Fox, however, while referring to the favorable reports of others, states that "he has not had successful results himself, possibly because he has not seen definite indication for the remedy"; sometimes it seemed to aggravate the malady ("Reynolds' System," ii., p. 884).

Gastro-enteritis—"English Cholera."—Fowler's solution is an effective medicine in severe cases of this disorder. I have seen it give relief when the patient was suffering from retching and bilious or sanguineous vomiting, passing white, odorless, or slimy flocculent stools, with pain, tympanitis, and tenesmus; other symptoms present have been—thickly-

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coated tongue, thirst, pyrexia and prostration, muscular cramps, scanty urine, pinched and anxious features. Even when the stage of collapse has commenced, and the surface is dusky and covered with cold perspiration, the medicine has seemed to me of great service—5 min. every one or two hours was the dose given, lessening it as the patient improved. Black has written very fully in praise of this remedy in English cholera, recommending 10 to 15 drops every ten to fifteen minutes till the symptoms abate, then less frequently. He has found this most valuable in various forms of choleraic attack, but especially in serious cases connected with defective drainage, and presenting the symptoms of vomiting, purging, and rapid collapse; he records several instances of immediate and striking improvement (*Lancet*, ii., 1857). Dr. Hitchman speaks equally strongly, and describes fully the indications for arsenical treatment in such cases (loc. cit., p. 535).

Cholera Infantum.—This term has been applied to dysenteric diarrhœa in children, probably because of the collapse so readily induced. The child looks pale and thin, and refuses food, the motions are very frequent and brown, offensive, and mixed with blood; tenesmus also is commonly present, and often with such symptoms minim doses of Fowler's solution produce excellent results.

Gastric Ulcer.—Not only in chronic inflammation, but in ulceration of the mucous membrane of the stomach, I have seen very beneficial results from arsenic, the appetite returning, and the thirst, the vomiting, and the pain subsiding, so that the patients became strong and stout who had before been weak and emaciated. Dr. Ringer has observed similar results, and states that he has seen relief from this remedy in chronic ulcer after failure of the more commonly-used medicines (Op. cit., p. 253). I usually prescribe 1 to 5-min. doses four times daily with a little nourishment.

Preparations and Dose.—*Acidum arseniosum:* dose, $\frac{1}{60}$ to $\frac{1}{12}$ gr. in solution or pill. *Liquor arsenicalis*—Fowler's solution (4 gr. in 1 fl. oz.): dose, 2 to 8 min. *Liquor arsenici hydrochloricus* (4 gr. in 1 fl. oz.): dose, 2 to 8 min. *Sodæ arsenias:* dose, $\frac{1}{16}$ to $\frac{1}{8}$ gr. *Liquor sodæ arseniatis* (4 gr. in 1 fl. oz.): dose, 5 to 10 min. *Liquor arsenici et hydrargyri hydriodatis* (not officinal): dose, 10 min. to $\frac{1}{2}$ fl. dr., diluted, and given with the usual precautions for preparations of arsenic. *Ferri arsenias:* dose, $\frac{1}{16}$ to $\frac{1}{2}$ gr.

Liquor arsenicalis, if long kept, is liable to vary in strength on account of the deposition of a thin film of metallic arsenic; the compound tincture of lavender contained in it is nauseous to some palates, and would be better omitted.

The solution of chloride is liable to become cloudy in warm weather, from the development of a fungus: this may be prevented by the addition of a little perchloride of iron (Hunt).

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In acute or subacute maladies, as of the stomach or intestine, small doses, 1 or 2 min., either every hour, or every four or six hours, are suitable; in chorea, or neuralgia, or struma, where there is no visceral irritation, the dose may be gradually raised to 10 or even 15 min., and in chronic conditions of ague, or of cutaneous disease, the secret of success will be found in securing the tolerance of a moderate dose for a considerable time.

In agues, it is true that a large dose may be required, and may be well borne during a certain condition of the system, but so soon as that condition is relieved the large dose cannot be tolerated.

In skin diseases, large doses are never desirable, and any increase beyond 4 or 5 min. should take place only after this dose has been used three or four weeks without physiological symptoms. This remark refers especially to the potash and to the acid solutions, not to that of the arseniate of soda, for although nominally of the same strength, the last-mentioned is markedly milder, and is often better borne in doses of 6 to 8 min., or more, than the others in less quantities. The remedy, sufficiently diluted, should always be given in several such moderate quantities daily, rather than in one full dose, and always at a meal, or with some food, so as to secure absorption and lessen the degree of local irritation; the symptoms of its physiological action, such as irritation of conjunctivæ, œdema, nausea, etc., should be constantly watched for, and the dose diminished rather than entirely omitted, if the reason for its administration remain.

In some obstinate cases, especially of chorea and of skin disease, it is justifiable and not harmful to keep up a moderate degree of physiological action for some time, but this must be done very cautiously. It is a matter of daily experience that the secretions must be in good order if we are to expect the full advantage of the remedy in chronic disease. Mr. Hunt observes, "Above all, the bowels must not be allowed to act sluggishly. In many cases a full dose of calomel and compound colocynth pill will be required two or three times a week, and these doses are sometimes essential to the cure. If the legs, or feet, or abdomen become œdematous, and the urine scanty, the case will not go on well till we have roused the kidneys to vigorous action by full doses of spiritus ætheris nitrosi and acetate of potash, etc." (*Journal of Cutaneous Medicine*, ii., p. 353).

The administration and the powers of arsenic in combination with other remedies require special consideration. We have already noted that it enhances the value of iron, for instance, in amenorrhœa, anæmia, struma, eczema, etc., and Messrs. Young and Postans have introduced a good effervescing citrate of arsenic and iron, which I have often found serviceable. The direct combination of iodine and arsenic has been esteemed by some practitioners on the Continent and in Ireland, especially by Neli-

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gan: from $\frac{1}{10}$ to $\frac{1}{4}$ gr. in pill thrice daily has been given. The same physician employed also an ioduretted solution, containing 5 min. of Fowler's solution, 1 gr. of iodide of potassium, and $\frac{1}{4}$ gr. of iodine in 1 dr. of orange syrup; it is rather agreeable, and keeps well, and has given good results. He found this preferable to Donovan's solution (*Dublin Journal*, vols. xvi., xviii., xxii.), (*v.* p. 27). This has been specially used in syphilitic skin disease, but it is, as Mr. Hunt observes, though "very active, yet a most unmanageable preparation." The mercury is liable to injure the general health of some weakly subjects, and to interfere with the effects of arsenic or of iodine, which are quite powerful enough, and require special caution as to their own effects. Dr. Clemens, of Frankfort, recommends a direct combination of arsenious acid and bromine, and Ferris and Co. prepare a liquor arsenici bromati.

[PREPARATIONS, U. S. P.—*Acidum arseniosum; Arsenici iodidum;* dose, $\frac{1}{60}$ to $\frac{1}{10}$ grain; *Arsenicum; Liquor arsenici chloridi;* dose, 2 to 8 minims; *Liquor arsenici et hydrargyri iodidi;* dose, 2 to 10 minims; *Liquor potassii arsenitis*—Fowler's solution; dose 2 to 8 minims.]

AURUM—GOLD, Au,=196.6 (not officinal).

This "king of metals," as it was formerly termed, is found native in the "veins" of rocks, and as gold-dust or nuggets in the sands of certain plains and rivers; it is separated by washing, or by means of mercury, which is afterward driven off by heat; it occurs also in alloy with silver, copper, and iron, but not as an oxide, nor in any other than the metallic form.

CHARACTERS AND TESTS.—When pure it is of yellow color, having a tinge of green by reflected light, and is decidedly greenish when liquefied; it is of great density (sp. gr. 19.5), and is remarkably malleable, 280,000 thin leaves making only one inch in thickness. It is less easily oxidized than any other metal, and will not combine with oxygen by direct action, only through the medium of another oxide: thus the protoxide of gold is prepared by adding solution of potash to one of protochloride; it precipitates as a green powder. Gold combines also with chlorine and iodine, not with nitrogen or hydrogen. It is soluble only in a mixture of nitric with hydrochloric acid (aqua regia).

PULVIS AURI—POWDER OF GOLD (not officinal).

PREPARATION.—By triturating gold leaf with some hard crystals, as of potassic sulphate, or with some glutinous substance as honey; and after

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complete disintegration of the metal, the foreign ingredient is removed by washing—the resulting powder retains the color of the metal.

Compounds of Gold.

AURI PERCHLORIDUM—PERCHLORIDE OF GOLD—"POTABLE GOLD" OF ALCHEMISTS, $AuCl_3$, =303 (*not officinal*).

Preparation, etc.—By dissolving the metal in nitro-hydrochloric acid, with gentle heat. On evaporating, yellow crystals of the salt are left in combination with some free acid ($AuCl_3 2HCl H_2O$). After the acid has been driven off, the color of the crystals is red, and they have the composition $AuCl_3$. This salt is used in photography and in analytical chemistry, and a solution of it, freed from excess of acid, is placed in the appendix to the Pharmacopœia as a test solution for atropia.

AURI PEROXIDUM—PEROXIDE OF GOLD—"AURIC ACID," Au_2O_3, = 441.2 (*not officinal*).

Preparation, etc.—By treating the perchloride with magnesia, washing the precipitate, and digesting in dilute nitric acid, which removes the magnesia. The peroxide forms, when dried, a brown powder, insoluble in water, and decomposed by exposure to light.

AURI ET SODII CHLORIDUM—CHLORIDE OF GOLD AND SODIUM, $AuCl_3 NaCl 2H_2O$ (*not officinal*).

Preparation, etc.—By mixing in solution about 5 parts of chloride of gold and 1 part of chloride of sodium, and evaporating to crystallization; long, four-sided prisms are left, of deep yellow color. This combination, which is deliquescent and soluble in water, is the form most commonly prescribed; it has a nauseous taste, and should not therefore be given in solution.

AURI IODIDUM—IODIDE OF GOLD, AuI_3 (*not officinal*).

Preparation, etc.—By mixing solutions of iodide of potassium and perchloride of gold. The precipitate, when collected, washed, and dried, forms a greenish yellow powder, insoluble in cold, but slightly soluble in boiling water.

Absorption and Elimination.—Salts of gold are readily decomposed by organic substances, and they coagulate albumen, but when the soluble chlorides are given internally they become absorbed to some extent,

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probably in the intestine, as oxides combined with albumen. When rubbed upon the gums and tongue, according to an old-fashioned method of administration, they are also absorbed, but are liable to cause much local irritation. Neither metallic gold nor the oxides can be absorbed (although poisoning by gold leaf is said to be an aristocratic method of suicide in China), nor is an ointment containing either these or the chlorides likely to produce any effect through the skin.

Elimination occurs through the liver, the intestinal canal, and the kidneys, but is very slow (Husemann): the urine is colored yellow during the process. Rabuteau maintains that the elimination of gold is never complete, some of the metal being reduced and deposited, especially in the epithelial and nerve-tissues; for on examining these parts in the body of a rat that had died after taking 15 gr. of gold chloride in fourteen days, he found the contour of epithelium from the intestinal tract to be very strongly marked, as by nitrate of silver, and the axis-cylinder of the nerve-tubules to be colored slightly green; he considers that this deposition of the metal explains why gold seems more active than mercury, for having nearly the same atomic weight and specific heat, their properties should (according to the analogies of other substances as observed by him) be also very similar, were it not that the gold is less completely eliminated (Op. cit.). We must remark, however, upon this point, that though mercury may, as a rule, be more readily eliminated than gold, yet it has also often been found deposited in bone, liver, and other parts of the body, long after its administration.

Physiological Action (External).—The chloride of gold has an irritant and caustic effect, and stains the skin of a yellow color, which becomes violet, and later black, from reduction of the metal.

Physiological Action (Internal).—*Digestive System.*—Small doses increase appetite and digestive power, and stimulate the secreting organs; but under larger or continued doses, this stimulation readily passes into irritation, and there are often dryness of the tongue, redness of the pharynx, and some gastric irritation, with colic and diarrhœa (Cullerier); on the other hand, though the intestinal secretions are increased, constipation has been noticed by several observers.

Glandular System.—Salivation has been commonly described as a result of this medicine, and is said to occur after a longer period, and with less marked stomatitis, than when produced by mercury. Martini met with it (ptyalism) only after the long-continued use of small doses, and found that the double chloride of gold and sodium might be taken for many months without injurious effect; only in one case did ptyalism occur, and then one-third of an ounce had been taken (Schmidt's *Jahrb.*, June 23, 1870). The secretion of the sweat-glands is increased, especially during the night, and this alternates with or accompanies an increase in the quantity of urine (Gozzi, Bologna, 1817). The stimulation of the glandu-

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lar system and of growth is said to be such that adenitis has followed the use of gold, and tumors of osseous or of glandular character have become painful and inflamed (Percy: *Rapport à l'Academie*). Some excitement of the genital organs occurs, so that in men priapism may be caused, and in women the catamenia increased (Legrand: "De l'Or").

Nervous System.—The intellectual powers are said to be stimulated by gold somewhat in the same manner as by alcohol.

Toxic Effects.—A peculiar febrile condition—"auric fever"—including headache and many of the above-mentioned symptoms, as sweating and diuresis, may supervene if a course of the remedy be continued for two to four weeks, and seems to be analogous to mercurial fever (Niel: *Recherches*, Paris, 1820, etc.). In animals, general emaciation and convulsive twitchings have preceded death, and besides the evidence of metallic deposition in the tissues, Rabuteau records a yellow coloration of the gastro-intestinal mucous membrane. Large doses of gold compounds may certainly cause gastritis and death, with cramp and other severe nerve-symptoms (Majendie).

SYNERGISTS.—Mercurials.

ANTAGONISTS—INCOMPATIBLES.—Albumen in any form—milk, flour, etc.

THERAPEUTICAL ACTION (EXTERNAL).—As a caustic, the chloride has been used by Landolfi and Recamier in lupus and in carcinoma. Legrand employed it as a caustic in ulceration of the neck of the uterus, and also as a lotion and a vaginal injection (Op. cit.). Mechanically, the gold leaf is employed by dentists for stopping teeth, and by druggists for coating pills.

THERAPEUTICAL ACTION (INTERNAL).—In former times, when fanciful analogies of color or of accidental qualities largely determined opinion as to the medicinal value of any substance, gold was praised as a remedy for melancholy, and for the dyspepsia often connected with it, and after several centuries of disuse its therapeutical power has been, to some extent, revived mainly by a few French and Italian physicians. The double chloride of gold and sodium is the preparation most recommended; it bears somewhat the same relation to the pure metal as corrosive sublimate does to mercury.

Syphilis.—M. Chrestien, of Montpellier, and later, M. Legrand, have reported many cases of both primary and secondary syphilis cured under the influence of gold, and Trousseau observes that such results are now well proven and incontestable. Chancres and condylomata have got well under this remedy in a manner not likely to be due to nature, and in my own experience its efficacy has been still better seen in the later developments, such as ulceration in the nose and larynx, cutaneous syphilides, hard nodes, etc. It is said to cure without local applications, but often an "unguentum auri" has been used in addition. Gold may especially

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be employed in long-standing cases with chronic periostitis, and when mercury has been already given to saturation.

Dietrich, while denying to gold any true anti-syphilitic power, thought it most valuable for mercurial cachexia (*Journal des Connaissances Med.-Chir.*, 1840), but this has not been corroborated by many observers. Auric fever may occur during a course of the remedy, and for a time the general health may suffer, and the local manifestations may be more irritable, but on lessening the dose, pyrexia subsides, and good effects are more conspicuous.

Scrofula.—Advocates of the medicinal use of gold—especially Niel and Legrand—have spoken strongly of its value in scrofulous disease of the bones, in glandular enlargements, "white swelling," goître, and even elephantiasis; but Velpeau and others have not corroborated their good results in hospital practice. No doubt, as Trousseau remarks, the treatment of scrofula among the poor really requires more than any drug can effect, and it would be unfair to discredit gold altogether because it has not cured some hospital patients. I think myself that it may prove a useful adjunct, or at least a good alternative treatment. Majendie and Roux have reported some illustrations of its value, and Mr. Chatterley has recorded a case of extensive and indolent scrofulous ulcer affecting the right foot, unrelieved by iodide of iron, etc., but cured by small doses of gold chloride (*Lancet*, ii., 1852, p. 455); also another case of cure of a cachectic child suffering from enlarged and indurated cervical glands (*Medical Times*, i., 1854, p. 447); he recommended $\frac{1}{24}$ gr. mixed with orris-root to be rubbed on the tongue for one to five minutes daily.

A case of hypertrophy of tongue with induration, which was probably syphilitic or scrofulous in character, was cured by the use of 1.5 gr. internally, and local frictions with 1 gr. mixed with lard (*American Medical Journal*, vol. xix., p. 514).

It is probable that the so-called cures of cancer by aurum have really been of scrofulous ulceration.

Uterine Disorders.—Nöggerath refers to the value of this medicine in amenorrhœa, and in chronic ovaritis, and says it is suitable for cases of the former dependent upon torpor; it should not be given during pregnancy, nor to persons liable to undue flooding. Martini states that it is serviceable in cases with a tendency to abortion, in chronic metritis, and in sterility "dependent upon atrophy of the vaginal portion of the uterus," also in ovarian dropsy. He observed benefit from it as regards mental symptoms of hysterical character, and especially when these were connected with definite uterine disorder or disease (Schmidt's *Jahrb.*, loc. cit.).

Chronic Bright's Disease.—Dr. Bartholow draws special attention to the value of salts of gold in the treatment of granular and fibroid disease of the kidney and "depurative disease." He has observed remarkable

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improvement from the persistent use of small doses of the chlorides—$\frac{1}{30}$ to $\frac{1}{20}$ gr., three times daily ("Materia Medica," p. 188). They are not suitable for acute stages.

Dyspepsia, etc.—Dr. Bartholow is also one of the most decided of modern writers in recommending small doses ($\frac{1}{20}$ gr.) of the double chloride for "nervous dyspepsia," as "indicated by a red glazed tongue, epigastric pain, increased after food, and tendency to relaxation of the bowels: also in duodenal and biliary catarrh, and jaundice." Vertigo and vertiginous sensations, connected with stomach disorder, are often relieved by small doses of gold chlorides, but plethora and increased intracranial blood-pressure contra-indicate their use. On the other hand, they do good in cerebral anæmia, so that they may be prescribed when bromides would not be suitable. Melancholia and hypochondriasis with depression are often connected with gastric disorder and with cerebral anæmia, and are susceptible, to some extent, of relief by the same remedy.

Hemi-Anæsthesia.—I must not omit to notice the most modern application of gold as a remedy, and that is in its metallic form in "metallotherapy," as developed mainly in Paris by Charcot and others. It seems that rather a large proportion of nervous patients on the Continent suffer from impaired sensation of one-half of the body, and that by the application of two metals, as a gold and a copper coin over several nerve-trunks, sensation may be "transferred," returning to the affected side in about a quarter of an hour, but often leaving, at the same time, the previously sound side. Such a peculiar circumstance is not yet wholly explained, but has been connected with a gentle galvanic action (*Medical Record*, 1878–79). Dr. A. Hughes Bennett and others explain the phenomena rather by "expectant attention," and I believe that mental influences of various kinds are a much more likely explanation than any specific properties of metals thus applied.

Preparations and Dose.—Fine gold, and the solution of the chloride, are placed in the appendix to the B. P., but no directions for their internal use are given. *Pulvis auri:* dose, $\frac{1}{4}$ to $\frac{1}{2}$ gr. gradually increased to 2 to 3 gr.—may be given in pill with confection of roses, but is not a good form. *Syrupus auri*, containing 24 gr. to the ounce, has been used by way of friction on the tongue, but cannot be depended upon. *Unguentum auri*, $\frac{1}{2}$ dr. to the ounce of lard—not dependable. *Chloride of gold and sodium:* dose, $\frac{1}{30}$ to $\frac{1}{10}$ gr. once or twice daily, in pill—the best preparation, but its irritant and poisonous properties should be remembered. *Teroxide of gold:* dose, $\frac{1}{10}$ gr. twice or thrice daily. *Iodide of gold* (French codex): dose, $\frac{1}{15}$ to $\frac{1}{10}$ gr., said to be more active than corrosive sublimate.

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BARIUM, Ba,=137.0.

A brilliant white metal, not met with in the native state, but abundantly as the base of an alkaline earth called *baryta* or *barytes* (an oxide), which occurs extensively as native sulphate ($BaSO_4$, heavy spar, its most common compound) and native carbonate (witherite).

BARYTA, BaO,=153.

CHARACTERS AND TESTS.—A grayish-white, earthy-looking substance, heavy, sp. gr. 5.4, of sharp caustic taste and strongly alkaline reaction; sprinkled with water it becomes hot, and slakes with energetic action, falling into a fine white powder,=hydrate of baryta, BaH_2O_2, which contains 10½ per cent. water, and is soluble in 10 parts of boiling water. Baryta has, like lime, a strong affinity for sulphuric and carbonic acids.

BARII CHLORIDUM—CHLORIDE OF BARIUM, $BaCl,2H_2O$,=244.

Is placed in the appendix as a test for sulphuric acid.

CHARACTERS AND TESTS.—Occurs in translucent soluble crystals, which have a bitter acrid taste. The solution gives with any soluble sulphate a heavy white precipitate, unaffected by nitric acid.

Carbonate of Baryta is a white insoluble powder.

ABSORPTION AND ELIMINATION.—We have no very accurate observations on these points, but Orfila detected the chloride of barium in the liver, spleen, and kidneys of animals poisoned by it (*Annales d'Hygiène*, ii., 1842).

PHYSIOLOGICAL ACTION (INTERNAL).—*Digestive System.*—Small doses ($\frac{1}{12}$ to $\frac{1}{8}$ gr.) of the chloride exert a stimulant effect on the stomach-functions, increase the appetite, and often produce loose stools. Larger doses prove irritant or caustic; three grains, taken several times daily, soon induce a sense of pressure at the epigastrium, nausea, vomiting, and purging, with faintness (Fergusson: *Dublin Journal*, February, 1844). One drachm caused much vomiting and purging, and death from convulsion in seventeen hours (Walsh: *Lancet*, 1859). Half an ounce caused similar irritant symptoms, and death in two hours—evidence of severe gastro-intestinal inflammation was found (Taylor). The nitrate and acetate of baryta have also caused death, and the carbonate is commonly used as a poison for rats and mice. Although one teaspoonful is said to have destroyed life, much larger doses have been taken without fatal result.

Nervous System.—The nerve-symptoms caused by toxic doses of barium compounds, are clonic convulsions and motor paralysis, with impair-

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ment of reflex excitability. From the slow respiration observed in cases of poisoning, it has been concluded that the vagi become paralyzed (Walsh). According to Cyon, the nerve-lesiōn caused is central, for even in advanced poisoning the muscular irritability and the sensibility of peripheral nerves remain intact (Reichert's *Archiv*, 1866, No. 2). Severe pains in head, throbbing in the temples, giddiness, dimness of sight, double vision, deafness, and tinnitus have been experienced: also muscular cramp, especially in the legs.

Circulatory System.—The heart-action is at first stimulated, afterward quickly and powerfully depressed, by full doses of barium compounds. After some palpitation, the pulse becomes irregular, feeble, or imperceptible, and the surface cold and pale. Bōhm concludes that they first stimulate and then paralyze the automatic heart-ganglia. Onsum suggested that baryta compounds caused embolism by precipitation of the sulphates of blood (Virchow's *Archiv*, Bd. xxviii.), but Cyon has shown both that the normal sulphates exist in very small amount, and that if they are artificially increased, still no precipitate occurs on giving baryta (loc. cit.).

Glandular System.—We have not clear evidence of the effect of baryta on this system, but it is presumed to exert some absorptive "deobstruent" power on inflamed or hardened lymphatic glands. Small doses increase the secretion of urine and of perspiration (Waring).

Synergists.—Lime and other alkaline earths. The chloride of barium has some analogies with corrosive sublimate.

Incompatibles.—All sulphates are chemically incompatible with barium salts, forming insoluble compounds. The sulphates of soda and magnesia have been used as antidotes in cases of poisoning (Walsh), also white of egg and sugared wine (Perondi: *Bulletin de Thérapeutique*, t. x.).

Therapeutical Action (External).—*Depilation.*—Dr. McCall Anderson recommends the sulphide of barium for removing superfluous hair, one part of it being made into a paste with four parts of zinc oxide and a little water; this should be left on the part for about three minutes, and then washed off.

Ophthalmia.—Dr. Pay recommends a collyrium of barium chloride (1 to 2 gr. in 10 oz.) in scrofulous ophthalmiæ (*Rev. Med.*, 1840), but it is not now much used.

Therapeutical Action (Internal).—*Scrofulosis, etc.*—Barium chloride was introduced at the end of last century as effective in scrofulous and syphilitic dyscrasiæ, in gonorrhœa, white swelling, etc. (Crawford, 1780). Lisfranc and Torget used it in such cases and in glandular tumors, and reported much advantage from it; the former began with $\frac{1}{8}$ gr. every hour, and increased the dose to much larger quantities than we should consider safe (40 gr.). In a child, many glandular tumors

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subsided under a month's treatment, but frictions with iodide of potassium were used at the same time (*American Journal*, 1838, No. 45, *Bulletin de Thérapeutique*, 1840). Mr. R. Phillips recommended barium chloride as superior to iodine in many cases marked by pallor, languid circulation, and irritable mucous membranes ("On Scrofula," 1846), and Mr. Balman used it in chlorotic and cachectic states generally (*Medical Times*, ii., 1851). In amenorrhœa he gave ½ to 1. gr. doses with perchloride of iron. Many cases of successful treatment of scrofulous joint-disease, of ophthalmia, and of enlarged glands by barium chloride (1/12 gr. doses), were recorded some years ago (Ranking, 1846).

Epilepsy, Tetanus, etc.—Hufeland introduced this remedy for epilepsy in scrofulous subjects, but it is now seldom used. Brown-Séquard, however, while reporting against its efficacy, remarks that it may diminish reflex excitability, and therefore deserves trial in tetanus and in paralysis agitans. A somewhat doubtful case of traumatic tetanus is said to have recovered under the use of about 16 gr. of the chloride, given in twenty-four hours (*Edinburgh Medical Journal*, 1862). In satyriasis, or excessive sexual desire, it has also been employed. Dr. Hammond recommends it in diffuse and multiple cerebral sclerosis.

Preparations and Dose.—*Barii chloridum:* the dose mentioned by Dr. Garrod and others is from ½ to 2 gr., but Mr. Kennedy, after much experience, maintains that 1/16 to 1/12 gr. is much more suitable and safer to commence with; very few persons, he says, can bear ⅛ gr. without irritation (*Lancet*, ii., 1873, p. 28). The United States Pharmacopœia contains a *liquor barii chloridi* (1 part in 4 of distilled water); the dose ordered is 5 min.

As an *eye-lotion*, from 1 to 2 gr. may be ordered with 10 oz. of water. As a *depilatory*, 1 part of sulphide to 4 of excipient.

[Preparations, U. S. P.—*Barii carbonas* and *Liquor barii chloridi.*]

BISMUTHUM—BISMUTH, Bi,=210—(Marcosita).

This substance, which is now, like antimony, classed among metalloids, occurs native, and also as an oxide, as a sulphide, and variously combined in metallic ores with silver, iron, copper, arsenic, etc.

Preparation.—The Pharmacopœia directs the preparation of a "*purified bismuth*," by fusion with nitrate of potash, but the process is not very satisfactory.

Characters.—The metalloid is gray-colored with a roseate tinge, and may be obtained in masses of cubical, iridescent crystals; it is tasteless and inodorous, heavy, hard, brittle, and, like antimony, volatilizes at a strong heat, and expands on cooling.

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BISMUTHI OXIDUM—OXIDE OF BISMUTH—BISMUTHOUS OXIDE—SESQUIOXIDE, Bi_2O_3, =468.

PREPARATION.—By boiling the subnitrate with excess of solution of soda.

CHARACTERS.—A smooth, yellowish powder insoluble in water, presumed to be more definite in composition, and more constantly pure than other bismuth compounds (R. W. Smith).

BISMUTHI SUBNITRAS—SUBNITRATE OF BISMUTH—WHITE BISMUTH—SPANISH WHITE, $Bi_2O_3.2HNO_3$, =546.

PREPARATION.—The true *nitrate* (ternitrate), which is crystalline, soluble, and more active and irritant than the subsalt, is formed by dissolving the metalloid in nitric acid, and when this solution is poured into a large quantity of water it is decomposed, the *subnitrate* of bismuth falling as a white precipitate, and the supernitrate remaining in solution.

It was known as nitrate in an earlier Pharmacopœia, and is still sometimes described under that name (Ringer); it has been termed also trisnitrate, and hence some confusion between the properties of really different compounds.

CHARACTERS AND TESTS.—The subnitrate is crystalline, but when well prepared, should be in smooth and fine powder. It is heavy, whitish in color, becoming yellowish-gray on exposure to light from the formation of some sulphide, or from the presence of silver; it is insoluble in water, soluble in nitric acid. It contains sometimes such an amount of acid as to effervesce when mixed with a carbonate (Martindale). A solution of bismuth subnitrate and sodium hydrate in water and glycerin is the Löwe test for sugar in urine: it has the advantage of being stable, and is recommended by Dr. W. G. Smith (*British Medical Journal*, ii., 1879).

LIQUOR BISMUTHI ET AMMONIÆ CITRATIS—SOLUTION OF CITRATE OF BISMUTH AND AMMONIA.

PREPARATION.—By dissolving purified bismuth in nitric acid, and then adding citric acid and solution of ammonia until the precipitate at first formed is redissolved. (A better form for this preparation has been published—*Pharmaceutical Journal*, 1866.)

CHARACTERS AND TESTS.—A colorless liquid, of saline metallic taste, miscible with water. Liquor potassæ precipitates the white hydrate, and hydrochloric acid the white oxychloride, but an excess of acid redissolves this as chloride. The officinal solution is described as neutral, or slightly

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alkaline, but it frequently contains an excess of nitric acid, much more than the original preparation of Schacht.

BISMUTHI CARBONAS—CARBONATE OF BISMUTH, $2(Bi_2Co_6)H_2O$, =1042.

PREPARATION.—By adding a concentrated solution of bismuth in nitric acid to an excess of carbonate of ammonia in cold solution.

CHARACTERS AND TESTS.—The salt which precipitates is a hydrated oxycarbonate, which is, like the subnitrate, insoluble in water, but is more soluble in the gastric juice, and has antacid properties.

On passing a current of sulphuretted hydrogen through an acid solution of a bismuth salt, the black sulphide of bismuth (Bi_2S_3) will be thrown down. Concentrated acid solutions of bismuth salts poured into water give a white precipitate of subsalt, *e.g.*, the nitrate when thus treated yields the subnitrate. Caustic alkali added to a solution of a bismuth salt precipitates the white hydrate of bismuth ($Bi_2O_3H_2O$). Papers saturated with sulpho-cyanide of potassium are colored yellow by soluble bismuth salts.

ABSORPTION AND ELIMINATION.—Bismuth, in substance, is not absorbed by the skin, and the supposed instances of poisonous effects from its use as a cosmetic are not trustworthy (Husemann). A soluble bismuth salt, such as the ammonio-citrate, is, however, quickly absorbed from the cellular tissue after hypodermic injection.

Much difference exists in the degree of absorption of bismuth compounds taken by the mouth, and the difference is proportionate to their solubility. The acetate, the double tartrate, and the ammonio-citrate dissolve in the gastric fluids, and are readily absorbed, while the oxide and subcarbonate are but slightly soluble, and the ordinary subnitrate still less so.

Headland taught that it was as insoluble as charcoal, but Orfila and Lewald have detected the drug in the liver, in the milk, and the urine, after its administration, though in the latter secretion it appeared later than other metallic salts usually do. Bergeret and Mayençon detected it in the same fluids, and in the serous exudations of dropsy, and after giving small doses to rabbits they found it, within half an hour, in the blood, the spleen, the muscles, etc., and continued to find traces of it for eight days after administration. In one man they also found it five days after; in another, testing sixty-two days afterward, they did not find any (*Journal de l'Anatomie*, 1873). We may conclude, therefore, that some amount of absorption even of the subnitrate occurs (and probably as chloride), although the greater part of what has been taken has been found unchanged in the stomach in some cases, or altered to a bluish tint in the small intestine, or converted into the black sulphide in the colon or rectum, or has been eliminated with the fæces during life. Dr. Levick

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mentions a case of phthisical diarrhœa, in which 20 gr. were taken four times daily for some weeks, and the whole intestinal canal was found to be lined by the bismuth powder (*American Medical Journal*, July, 1858). It is probable that more absorption occurs with small doses (such as the grain or less used originally by Odier, of Geneva), than with the very large ones (several hundred grains daily) prescribed by Monneret.

PHYSIOLOGICAL ACTION (EXTERNAL).—The pulverulent bismuth compounds have an absorbent and protective effect: they are also somewhat astringent and sedative. The crystallized nitrate, especially when dissolved in glycerin, is also astringent, but is more irritating, even somewhat caustic.

PHYSIOLOGICAL ACTION (INTERNAL).—*Digestive System.*—Bismuth, taken in a pulverulent form, exerts upon the gastric mucous membrane a sedative, slightly astringent effect, similar to that already described as its external action. Taken in a liquid (more soluble) form, the effects are still of the same kind, but produced by smaller doses and with more tendency to irritation. Whether pure bismuth salts, when taken internally, can exert an irritant poisonous action, or are in the largest doses practically innocuous, has been much disputed. Orfila and Meyer, in experiments on animals, found that both the nitrate and the subnitrate, in doses of 1 to 2 dr., caused vomiting, tremor, depression, and death, with post-mortem evidence of gastro-enteritis ("Toxicologie," ii., p. 10; and Wibmer: "Wirkungen," etc., i., p. 423). Kerner also records a case of a man who took 40 gr. of the subnitrate, and suffered from gastric oppression, and burning pain, bitter taste, thirst, loss of appetite, eructation, griping, bilious vomiting and relaxation, with vertigo, dimness of sight, and headache—the pulse was small and tense; and another case—a man who swallowed 2 dr. (mixed with cream of tartar), and died after violent symptoms of irritant poisoning, such as burning pain in the throat, purging, vomiting, cramps, suppression of urine, tremor, and paralysis: after death, inflammation and even gangrene were found in the course of the alimentary tract (Wibmer, loc. cit.). Sobernheim subjoins to these cases, one that after a 2-dr. dose proved fatal in nine days, with similar symptoms, including also delirium and general swelling of the face, limbs, and abdomen: in this instance also, inflammation and gangrene of the stomach and intestines were found ("Arzneimittellehre," 6th Ed., p. 265). Trousseau alludes to a similar case recorded by Pott in 1739, and Dr. Traill reports one where vomiting and pain followed the taking of 6 dr. (in divided doses). Christison describes "bismuth, in its saline combinations, as an active poison," and Taylor quotes some of the above cases as "proving that a substance very slightly soluble in water may exert a powerfully poisonous action on the human system."

On the other hand we must place the strong evidence of Trousseau and Monneret, and the daily experience of a majority of practitioners.

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Trousseau states that during a very extensive use of the well-prepared subnitrate in doses of from 15 to 60 gr., he has never seen the slightest accident, or the least cause for apprehension ("Materia Medica," i.), while Monneret prescribed the enormous doses of 150 up to 900 gr. per diem, without any inconvenience resulting. He noted only slight constipation with lessened odor and blackened color of the fæces; there was no thirst, nausea, or pain, nor any evidence of inflammation, and the appetite was rather increased than diminished. Such doses as the above are not likely to be now prescribed, but many physicians order 10, 20, or 30 gr. several times daily without any evil result.

Trousseau and others explain the toxic symptoms above noted by the presence of *arsenic* as an impurity, and in some cases correctly, as shown by Taylor. H. C. Wood also records a case of bloody purging from the use of an adulterated drug, and the effects are certainly those of an irritant poison. Still, as a rule, there is no evidence of the requisite amount of arsenic for serious results, even in the most adulterated specimens of bismuth. Stillé speaks of one-sixth of 1 per cent. as the maximum proportion found, while Parral and Garnier ascertained that preparations containing 0.129 per cent. did not poison dogs, even in doses of 200 to 500 gr. (*see* also Adulteration).

Monneret suggested that in the above cases, either a previous illness became suddenly exaggerated, or an excess of *soluble nitrate* acted as an irritant: the last alternative seems possible after recent evidence that soluble compounds of bismuth have an activity hitherto not supposed in pure preparations. The acetate (according to Bricka), the double tartrate (Rabuteau), and the ammonio-citrate (Stephanowitsch) given in large doses, produce poisonous symptoms very like those of the allied metals, gold and quicksilver. Rabuteau "at first held the classical opinion as to the remarkable harmlessness of bismuth," but his observations with the double tartrate, or "emetic" of bismuth and potash ($C_4H_4K(BiO)O_6$) have convinced him that *slight solubility* explains the general absence of dynamic effects after large doses of the ordinary preparations. The tartrate is soluble in water without decomposition, and gives a metallic taste like that of ordinary "tartar emetic," it causes vomiting, and 30 to 60 gr. prove fatal to small dogs. In connection with this observation, it is noteworthy that in Kerner's fatal case, the patient took cream of tartar with his dose of bismuth, and the salt referred to by Rabuteau would probably be formed. Stephanowitsch records of the ammonio-citrate that its hypodermic injection, in the proportion of 1 gramme to each 1,000 grammes of body-weight, will kill animals, and that salivation and buccal abscess follow its use, as well as steatosis of liver, kidneys, and heart. The liver glycogen disappears under its prolonged administration (Lebedeff).

Although, therefore, some of the older cases were connected with the

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presence of arsenic, yet bismuth cannot be held entirely innocuous, and its activity clearly depends upon its solubility. The oxide, the subcarbonate, and subnitrate, though but slightly soluble, may be taken up to some extent, especially when small doses are used. Thus, Odier, of Geneva, gave only a few grains, or less than a grain, and noticed occasionally vomiting, diarrhœa, a sense of heat, vertigo, and drowsiness. M. Guersant has noted colic and "sense of anxiety," and Rabuteau some general sedation, like the effect of antimony, and I have observed some clinical evidence in the same direction; but the existence of a chronic form of bismuth poisoning, marked by anæmia, swelling of gums, hemorrhage, etc., as described by Lussanna in man,[1] and by Stephanowitsch in animals, has not been further verified. The only observation bearing upon it that I have found is one by Dr. Brinton, who states that if the subnitrate be taken continuously it will cause a bluish-red line on the gums, "similar to, but wider and more red than that known to be caused by lead" ("Diseases of Stomach," first edition, p. 197). I have not found this noted by any other observer, but lead has been suggested as an adulterant in the preparations used by Lussanna.

The action of *Liquor Bismuthi* differs somewhat from that of the solid compounds, and probably represents rather the real activity of the drug, independently of the mechanical effect of a powder; it is more irritant (H. Wood), and it has failed to relieve gastric pain when the subnitrate has succeeded (Macnamara). The carbonate is said to be less liable to irritate than the subnitrate, and yet to be more soluble in the gastric juice (Hannon); it does not perhaps absorb intestinal gases so readily as the subnitrate or oxide, but has better antacid powers, and is not so likely to constipate. The observer named, traced to it also some primary sedative effects, like those described by Rabuteau of the nitrate, viz., weakening and slowing of pulse, lessened appetite, and increased excretion of urine, but found that its continued use improved strength and vigor like iron preparations.

Synergists. — Mechanical absorbents and antacids and sedatives. Magnesia is specially suited for combination with bismuth salts.

Incompatibles.—Acids are said to be incompatible with the subnitrate of bismuth (Gubler), and some have advised the omission of all acids from the diet during its administration. Practically, however,

[1] Dr. Lussanna remarks that Monneret's results with large doses "have destroyed the Orfilian scarecrow," but his own conclusions are almost as alarming as those of Orfila. From large doses, used apparently chiefly in tuberculous diarrhœa, he witnessed no irritation, nor any arrest of the malady, but supervention of a "colliquative and scorbutic state," connected, he presumes, with a solvent action on globulin—he traces a profuse epistaxis in a case of mesenteric tuberculosis to the use of bismuth, but gives no sufficient details of the cases on which his exceptional conclusions are based.

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their effect is only to favor the production of the more soluble nitrate, which should, in suitable dose, act favorably without discomfort, and a few minims of nitric acid are not infrequently prescribed with it; they should be omitted, however, if a merely protective effect is desired from an insoluble preparation. Bismuth prescribed with a strong solution of iodide of potassium precipitates as a red iodide, which is insoluble and apparently inactive (*British Medical Journal*, ii., 1870).

THERAPEUTICAL ACTION (EXTERNAL).—*Erythema, Eczema, etc.*—In these and allied forms of congestive and inflammatory skin disease, bismuth compounds are often extremely useful, by virtue of their absorbent, astringent, and soothing properties. In erythema and erysipelas, intertrigo, and bedsore they may be applied in powder, alone, or diluted with starch or magnesia, or made into a cream with water and glycerin, or into an ointment in the proportion of 30 to 120 gr. in the ounce of prepared lard, cold cream, or vaseline. (Dr. McCall Anderson, in praising this ointment, notes that it should not be made with *benzoated* lard, or else, for some unexplained reason, it becomes liable to irritate.) An oleate of bismuth is also a good preparation: according to Dr. Louis Lewis, oleic acid may be made to take up 20 per cent. of oxide (*Pharmaceutical Journal*, December, 1876).

In the acute stages of eczema, when there is much irritability and much serous discharge, these preparations are also very serviceable; they seem to be sufficiently astringent, yet not so much so as lead, zinc, or tannin, and will often act better than those remedies. In later stages, when there is infiltration with redness and scaliness, a stronger solution of the soluble nitrate in glycerin becomes suitable.

In the erythema connected with acne of the face, bismuth forms a good ingredient in soothing lotions: a small quantity of corrosive sublimate (2 gr. to 8 or 10 oz. of liquid) is often combined with great advantage, when sulphur and other stimulants could not be borne.

As a cosmetic under the name of "blanc de perle," bismuth salts have long been celebrated: they are liable to become darkened by contact with sulphur in any form (*e.g.*, the sulphuretted hydrogen of ordinary gas, etc.), some proportion of the black sulphide being generated.

For chaps, and fissures about the hands, lips, nipples, etc., bismuth ointment is very good, and especially with a little tincture of benzoin (20 to 30 min. to 1 oz.). Trousseau specially commends it for anal fissure (*Bulletin de Thérapeutique*, v., p. 63), and others for ulceration of the septum nasi, and excoriations of the cervix uteri. Follin used a glycerole, containing 1 or 2 parts in 3 of the liquid, for chronic granular conjunctivitis.

Catarrh—Chronic Discharges.—Monneret recommended the insufflation of bismuth powders for coryza, and in chronic catarrhal conditions Soubrier used a snuff containing 4 parts of the subnitrate with 8 of

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liquorice and 30 of iodide of sulphur (*Bulletin*, 1859). For acute cases Dr. Ferrier has lately reintroduced a formula containing ½ to 1 gr. of morphia, well triturated with 60 gr. each of the subnitrate and of gum acacia, and this often acts well in cutting short a troublesome "cold in the head;" this I have frequently prescribed, but find patients discontinue it on account of its causing frontal headache and clogging of the nostrils. In leucorrhœa bismuth has been applied in powder or paste, on charpie, or as injection in the proportion of 1 to 8 of water, and has been used with advantage in gonorrhœa and gleet (Caby).

THERAPEUTICAL ACTION (INTERNAL).—*Dyspepsia.*—According to Monneret, "pain arising during digestion, from whatever cause," may be relieved by mixing the subnitrate freely with the food, but more definite indications may be given. Gastric pains dependent on indigestible food, marked constipation or hepatic congestion, require emesis or purgation, while in vomiting connected with fermentation of food, dilatation of stomach, etc., antiseptic remedies and perhaps washing out of the viscus may be necessary.

Bismuth is specially indicated in cases of difficult digestion with tendency to diarrhœa, in subacute or chronic gastritis, and gastralgia with marked irritability of mucous membrane: for such cases, Odier first introduced it (in Geneva, 1786); he describes severe gastric pain as frequent among the servants there who lift and carry on their heads large vessels of water—the pain was either spasmodic, sudden, intense, and relieved by pressure, or more persistent and accompanied with sensations of gnawing, sinking, and pulsation; eructation, nausea, and vomiting occurred in greater or less degree, and the general health and mental state became much depressed. Such cases were much relieved by bismuth in moderate doses; and Marcet, Bardsley, and other English physicians have published similar experiences.

Nothnagel finds it especially useful when pain occurs after food in badly nourished overworked persons; but when there is marked anæmia or a general neuralgic condition it is not so serviceable alone, nor is it very permanent in its good effects. Prussic acid, or opium, alkalies, and later iron and bitters, may be conjoined with it. Caizergues especially praises a combination of 4 gr. with ⅛ gr. of extract of belladonna in the gastralgia of chlorosis (*London Journal of Medical Science*, 1851).

When *acid pyrosis* is a marked symptom, bismuth is particularly indicated either alone, or, if acidity be marked and constipation usual, then combined with magnesia. According to Trousseau, if the rejected fluid be insipid, glairy, or sour ropy phlegm, bismuth alone is contra-indicated, but in most cases it deserves trial, requiring only that constipation be remedied. The nausea and vomiting of gastric irritation is commonly amenable to bismuth, *reflex* vomiting, such as that of pregnancy, not so

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(Husemann); this is an argument in favor of the local protective effect of the drug.

In *infantile vomiting*, which is frequently dependent on acidity or ill-digested food, and accompanied by diarrhœa and pain, bismuth is exceedingly useful, being, as it is, practically harmless and tasteless—1 to 2 gr. may be placed on the infant's tongue with a moistened finger. A minute dose of creosote, $\frac{1}{10}$ of a drop, may often be usefully combined (*British Medical Journal*, ii., 1875).

In *Ulceration of the Stomach*, when pain is very severe and exhausting, and when vomiting is frequent, much relief may be given by full doses; and I have noticed that distressing thirst has been rather relieved than increased by the remedy. Dr. Brinton attached great value to it; it is often given with opium in such cases.

In *Malignant Disease* even, I have found bismuth palliate for a time the most severe symptoms; and in both these conditions it acts mainly by forming a smooth layer over exposed and hypersensitive nerves, and so preventing the contact of food and unhealthy secretions: to obtain such a result it is evident that more than ordinary doses are required.

Gastro-Uterine Irritation.—Trousseau undervalued the virtues of bismuth when he held it unsuited for gastric pain connected with leucorrhœa. It has really a special sphere of action in various uterine disorders which induce or follow on gastric derangement, as has been well shown by F. W. Mackenzie (*London Journal of Medicine*, 1857). His cases seemed to prove the stomach primarily at fault, since complaint was made of pain, sinking, flatulence, etc., before the ordinary symptoms of uterine irritation appeared; bismuth greatly relieved them, and my own experience is somewhat to the same effect. In dysmenorrhœa, with severe pain in the back, hips, legs, and hypogastric region, palpitation, etc., I have often given it with good effect, and in uterine hemorrhage (profuse menstruation) it has proved strikingly efficacious when recognized styptics had failed, being thus allied in action with oxide of silver and arsenic; apparently a sedative influence is exerted both on the stomach and the uterus through the mucous tract and connected nerve-ganglia.

Diarrhœa.—In irritative diarrhœa, with red tongue, nausea, heartburn, griping pain, worse after meals, and frequent ill-formed stools, I have found bismuth invaluable. In some persons, mostly women, such a condition becomes habitual, and even ordinary articles of diet may cause severe aggravation of symptoms; the constant use of this remedy, however, gives them the greatest relief, and enables them to take food with comparative comfort; much flatulence is often present, and sometimes the diarrhœa depends on irritation from the development of sulphuretted hydrogen (Chambers). Bismuth is then also very suitable, for it combines readily with that gas and absorbs it (*Practitioner*, 1869); sometimes

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charcoal, or aromatic chalk powder, or rhubarb, may be added with much advantage.

Infantile Diarrhœa.—When infants at the breast suffer from eructations, sour vomiting, diarrhœa, light-colored papescent stools of bad odor, with crampy pains in the stomach, I have always found bismuth act well. In that form of diarrhœa which so readily affects children while being weaned, or during hot weather, or that which continues even after irritation has been removed, it is also of great service; from 1 to 5 gr. may be given several times daily to children of one year and under. Weller prescribed for children as much as 30 to 60 gr. of subnitrate every hour (interdicting milk during the treatment), with no other than good results (*Deutsches Archiv*, quoted *American Journal*, 1870).

The *ulcerative diarrhœa* and aphthous condition connected with phthisis is alleviated by full doses. Traube (one of the first to recommend the remedy in such cases) supports the view of its acting mainly as a mechanical protective, lessening local irritation, and consequently reflex peristalsis. We have already referred to a case in which the powder was found to line the whole tract, and it is evident that for such protective effect large doses are necessary. Dr. T. Thompson, who prescribed about 5 gr. of the subnitrate with magnesia and mucilage, and Monneret, who gave many drachms for a dose, are strong advocates of its advantages. The latter observer states that he had seen many persons who were apparently dying with tuberculous diarrhœa, restored for a time to comparative health ("Medico-Chirurgical Transactions," v., p. 31, and *Bulletin*, v., p. 47), but the results of others have not been so favorable. The persistent diarrhœa of enteric fever is sometimes well treated in the same manner.

Dysentery.—M. Brassac, of the French naval service, records the best results from bismuth in epidemic dysentery. Finding little or no benefit from small doses, he followed the teaching of Monneret, and beginning with 230 to 300 gr. daily, increased to more than 1,000 gr.; he divided this into about five doses, according to the case, giving it in broth or milk, or sometimes by enema, and so long as more than one stool occurred in the day. This plan was very successful, and had no ill result; as a rule, his patients began at once to eat better and to gain strength (quoted *Edinburgh Medical Journal*, 1867). Trousseau also used bismuth injections in dysentery (*Lancet*, i., 1855), and more recently Dr. Houghton writes from Borneo, concerning their great value in subacute and chronic cases in tropical climates; he prescribes 30 gr. with mucilage to be injected two or three times daily, and retained if possible (*Lancet*, ii., 1879). In acute and chronic colitis, Lasèque also used, with the best results, enemata of 30 to 150 gr. with egg or mucilage.

Cholera.—In the epidemic at Warsaw, in 1831, it was highly approved by Leo, and in later epidemics at Paris it was commended by

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Trousseau, and very largely used for the premonitory diarrhœa; at the commencement of the attack only, a little opium may be added with advantage; afterward, two full doses of bismuth daily will suffice.

The reputation which has been sometimes claimed for bismuth as a valuable remedy in intermittent fever, and in nervous disorders, as epilepsy, cephalalgia, asthma, and in whooping-cough, must be traced either to its relieving gastric complications of such maladies, or to the presence of contained arsenic: it has not been sustained in recent times.

PREPARATIONS AND DOSE.—*Bismuthi oxidum:* dose, 5 to 15 gr. or more. *Bismuthi subnitras:* dose, 5 to 20 gr. or more (see below). *Trochisci bismuthi:* dose, 1 to 6 lozenges (each lozenge contains 2 gr. with lime and magnesia). *Liquor bismuthi et ammoniæ citratis:* dose, ½ to 1 fl. dr. and upward (contains 3 gr. of oxide in each fluid drachm). The preparation of Schacht is said to contain only 1 gr. of oxide in each drachm: dose, 1 to 4 dr. *Bismuthi carbonas:* dose, 5 to 20 gr. or more.

Preparations of bismuth should be taken about a quarter of an hour before, or with meals, and if a mechanical protective effect is most desired, acids are better avoided during the medication.

Subnitrate.—The dose should depend upon its molecular state. Thus, if it be very dry and likely to become caked together in the stomach, very large doses may not act at all, or may cause irritation, while if moistened or formed into hydrate, or carefully mixed with some other fine powder, moderate doses will give a much better result. Thus, Quesneville took 80 grammes without much advantage, but afterward using the drug thoroughly soaked in water, soon obtained good effects with 5 to 10 grammes; his "*bismuth-cream*" is a valuable preparation, better known abroad than in this country. Doses of 1½ to 2½ dr. are now seldom used, 5 or 10 gr. representing an average prescription for adults. Much more may, however, be given in organic disease when there is erosion or ulceration of the alimentary surface; milk or almond emulsion is a good vehicle. The subnitrate forms a part of the "*poudre de Wendt,*" also of the powder of Robert Thomas; combined with magnesia it is "Patterson's, or American powder," and with pepsin, the "*poudre de Royer.*"

The liquor bismuthi et ammoniæ citratis is miscible with water and spirit, but not with alkalies without precipitation. The so-called "lac bismuthi" (Symes) contains the hydrate mechanically suspended.

A lactate, a tannate, and a valerianate of bismuth have been described: the first is a soluble salt, and may be given in small doses; the compound with tannin is designed to favor its astringent, and the valerianate any nerve-tonic powers. A citrate of iron and bismuth is sometimes useful.

Besides these, there are many private preparations, as of bismuth and pepsin, bismuth and strychnia, etc.

A glycerole of the neutral nitrate is best prepared by dissolving ½ oz.

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of the crystallized salt in 2 dr. of pure glycerin and an equal quantity of distilled water, afterward adding glycerin to 6 oz. *Unguentum bismuthi* may be prepared with ½ to 1 dr. of any bismuth salt in 1 oz. of cold cream (not benzoated). An *oleate* is made with oleic acid and the oxide in strengths of from 10 to 20 per cent. A lotion or injection is made with 1 part to 8 of liquid. Pessaries are made containing 15 gr. in each.

[PREPARATIONS, U. S. P.—*Bismuthum*, *Bismuthi subcarbonas*, and *Bismuthi subnitras*.]

ADULTERATIONS.—Besides being variable in its chemical constitution, in the amount of oxide and of acid present, the subnitrate may contain added carbonate, and phosphate of lime, carbonate of lead, subchloride of bismuth, and other metals introduced in the process of manufacture, also certain natural impurities not removed—*e.g.*, traces of iron, copper, silver, and arsenic. The last is the most important, although no official test for its presence in bismuth is given. In the older preparations it was probably always present, and, so long ago as 1743, Geoffrey expressed his fear of bad results from it ("Materia Medica"). In later times, Dr. Taylor found it in three out of five specimens; and Mr. Edin found it in many specimens of liquor bismuthi when it was first introduced (*Pharmaceutical Journal*, 1868).

The practical bearing of such adulteration was illustrated in a trial for arsenical poisoning at Philadelphia about twenty years ago. It was proved that bismuth "nitrate" had been prescribed shortly before death: a specimen of the particular salt dispensed could not be found, but, of ten others purchased in the city, a majority contained arsenic, and although the irritant symptoms had commenced before bismuth was prescribed, and the proportion of arsenic found in the viscera was much more than bismuth adulteration would account for, yet the trial was stopped, and the accused person discharged (*American Medical Journal*, July, 1858).

At the present time, however, adulteration with arsenic is exceptional. Of six chance specimens examined under the direction of Dr. Anstie, not one contained it (*Practitioner*, 1871); and Professor Siebold, after much experience, reports that it is now rarely found (*Pharmaceutical Journal*, December, 1875). Of seven samples of the basic nitrate of the United States Pharmacopœia, one only contained arsenic—.33 per cent. (Op. cit., November, 1875). In the oxide he often found traces of sodium and lead, and commonly subchloride and subnitrate.

Selenium and *tellurium* have been found in some specimens of bismuth salts, and a Colorado ore of the metalloid has been found to contain 34 per cent. of tellurium. This may explain the offensive alliaceous odor which is sometimes given to the breath by special samples of bismuth preparations. It resembles that of arseniuretted hydrogen, and has naturally been attributed to that gas, and yet not correctly; and the absence of the poison in certain offending samples has been proved by analysis

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(*Pharmaceutical Journal*, December, 1875); neither can the odor be traced to prussic acid or other usual ingredients in bismuth mixtures: while we know that tellurium can impart an offensive odor, for Sir James Simpson made trial of the drug, and Dr. Maclagan relates that on one occasion a student took a dose which obliged him to sit apart from the class for the rest of a session! (*Edinburgh Medical Journal*, December, 1854).

The carbonate of bismuth is liable to contain chlorides, also sodium, and sometimes lead. In five specimens examined by Prescott no arsenic was found (*Pharmaceutical Journal*).

CADMIUM, Cd,=112.

This is a somewhat rare metal, found associated with zinc in nearly all its ores, and obtained from these by distillation.

CHARACTERS AND TESTS.—Tin-white and lustrous, fibrous in fracture, ductile and malleable, of sp. gr. 8.6 to 8.9. In air, at ordinary temperatures, it tarnishes gradually; heated strongly it takes fire, and burns to a brown oxide, CdO; at 176° F. it becomes very brittle, and fuses at 442° F. Treated with dilute mineral acids, it sets free hydrogen, and forms a colorless solution; this, when further diluted, gives with sulphuretted hydrogen a bright yellow precipitate of cadmium sulphide (CdS), insoluble in ammonium sulphide. Caustic and carbonated alkalies give with cadmium salts gelatinous white precipitates, which, except in the case of ammonia, are insoluble in excess. Zinc precipitates metallic cadmium.

CADMII IODIDUM—IODIDE OF CADMIUM, CdI_2,=366.

PREPARATION.—By the direct combination of the metal with iodine in the presence of water.

CHARACTERS AND TESTS.—Occurs in flat, micaceous white crystals, of pearly lustre, which melt at 600° F. into an amber-colored fluid; they are anhydrous, permanent in air, but decompose at a dull-red heat, with evolution of iodine in vapor. In water and spirit they are freely soluble, the solution being acid to test paper, and answering to the tests for cadmium already mentioned.

The Sulphate of Cadmium is officinal in the United States. It occurs in oblique, rhombic prisms, translucent and colorless, like those of zinc sulphate; it has an acid, astringent taste, effloresces on exposure, and dissolves readily in water.

The Bromide of Cadmium resembles the analogous salt of ammonium, and has been taken by mistake for it; it is used in photography.

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Absorption and Elimination.—Cadmium salts coagulate and combine with albumen, but these albuminates dissolve in an excess of the salt, especially in excess of a double salt, such as the chloride of cadmium and sodium; even in alkaline chlorides they are partially soluble, so that we can readily understand their absorption from the stomach. Absorption occurs also after their injection into the cellular tissue, the bowel, etc., as evidenced by the finding of cadmium compounds in the organs and secretions (Marmé: *Schmidt's Jahrb.*, iii., 1867).

Elimination of the drug begins soon after its administration, and takes place mainly by the kidneys.

Physiological Action (Internal).—*Digestive System.*—Cadmium compounds, except the sulphide, resemble each other in action. The sulphide, though considered poisonous by van Hasselt, has been given to animals in drachm doses daily for a week, without evident effect, and is therefore pronounced inert by Marmé. The oxide, chloride, sulphate, iodide, etc., given in doses of ½ to 2 gr., cause pain at the epigastrium, vomiting, and purging, and in somewhat larger doses gastro-enteritis, which may pass on to ulceration. Similar effects follow their hypodermic injection, and after toxic doses given in this manner, the gastro-intestinal mucous membrane has been found inflamed; irritation and suppuration also occur at the site of injection. The continued administration of small doses induces a chronic form of poisoning marked by dyspepsia and emaciation, which in animals has terminated in death from exhaustion. In the case of two ladies who took by accident a quantity of bromide of cadmium (not less than 5, or more than 16 gr). pungent taste and sensations in mouth and throat were felt, and burning pain at the epigastrium, vomiting and purging set in, and continued for five hours, and after recovery the stomach remained very irritable (Wheeler: *Boston Medical and Surgical Journal*, October, 1876). In a man who took 9 gr. of a cadmium salt, salivation, colic, and catharsis followed in the course of an hour, and four hours afterward, violent vomiting, gastralgia, and tenesmus (Burdach). In a dog, death has followed the injection of ¼ to ½ gr. into a vein, or the giving of 5 to 9 gr. by the mouth.

Nervous and Circulatory Systems.—Foret has described, in cases of poisoning by cadmium carbonate, besides the symptoms of gastric irritation—giddiness, prostration, loss of consciousness, cramp, and slowing of respiration and heart-action. In the ladies above mentioned, somnolence was marked after subsidence of the irritant symptoms.

Synergists.—Salts of zinc and lead.

Antidotes.—In acute poisoning by cadmium salts, the alkaline carbonates with albumen (white of egg) are the best antidotes. In Marmé's experiments, injections of dilute soda solutions into the stomach soon after the exhibition of the poison quite prevented bad effects.

Therapeutical Action (External).—The only officinal salt, the

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iodide, is used in the form of ointment in glandular scrofulosis, and has been recommended by Guibert and Garrod. Other physicians have prescribed it in splenic enlargement and in strumous skin disease (Waring). I have used it repeatedly in cases of enlarged glands, of nodes, and of chronic joint inflammation, with satisfactory result. It does not stain the skin, like iodide of lead, but is liable to cause irritation unless diluted.

In *Ophthalmic Surgery* cadmium sulphate has been used more as an astringent in lotion or ointment for dyscrasic inflammation of the eye, and for corneal opacities (leucoma), (Gräfe, Kopp, Middlemore).

THERAPEUTICAL ACTION (INTERNAL).—The sulphate of cadmium has been recommended in syphilis, rheumatism, and gout (Grimand), but there is, at present, little evidence of its special powers.

Gonorrhœa—Leucorrhœa.—In these maladies injections of sulphate of cadmium have been used by Lincke, but possess no evident advantage over injections of sulphate of zinc.

PREPARATIONS AND DOSE.—*Unguentum cadmii iodidi* (contains 62 gr. in 1 oz. of simple ointment). *Cadmii sulphas:* dose, $\frac{1}{12}$ to $\frac{1}{2}$ gr.; for *collyrium*, $\frac{1}{2}$ to 4 gr. in 1 oz. of rose-water (Fronmuller); for *ointment*, 4 gr. in 1 oz. of lard; for *injection*, 2 gr. in 1 oz. of water; these formulæ seem somewhat inconsistent with Bouchardat's statement that the salt is ten times as powerful as the sulphate of zinc.

[PREPARATIONS, U. S. P.—*Cadmium* and *Cadmii sulphas.*]

CALCIUM—LIME, Ca,=40.

Calcium is a grayish-white metal, the basic radical of lime, and its compounds: as a carbonate it occurs naturally in chalk, marble, etc.; as a sulphate in gypsum; as phosphate and carbonate in shells, bones, and various organic tissues; and as silicate and fluoride in various minerals and vegetables. When heated, it becomes quickly oxidized and converted into *lime*—calx: inflamed, it burns with a bright light.

CALX, CaO,=56—*LIME—QUICK-LIME.*

PREPARATION.—Lime is commonly prepared from its carbonate (marble or limestone) by heating it to full redness to drive off the carbonic acid.

CHARACTERS AND TESTS.—A grayish-white solid, of sp. gr. 3.18, of alkaline, caustic taste. When water is poured on it to the amount of about three-fourths of its weight, it swells up, evolving great heat (up to 500° F.), and falls into a soft, white powder, in which the oxide is com-

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bined with one molecule of water (hydrate of calcium, CaH_2O_2, =74); the process is called "slaking."

CALCIS HYDRAS—SLAKED LIME, CaH_2O_2, =74.

PREPARATION.—From quick-lime, as already described.

CHARACTERS AND TESTS.—The hydrate of lime, though it can absorb 31 per cent. of its weight of water, remains perfectly *dry*, and is itself very sparingly soluble in water (1 in 900), and less soluble in *hot* than in cold water; at 32° F. twice as much lime is dissolved as at 212° F. At ordinary temperatures water dissolves only about ½ gr. to the ounce, but its solvent power is increased by syrup or by glycerin to the extent of nearly 8 gr. to the ounce. Lime does not melt at the highest temperature, and hence its use for the electric and oxyhydrogen lights; sp. gr. 2.078.

The chief test for lime is the white precipitate formed with oxalate of ammonium, insoluble in acetic acid, but soluble in hydrochloric or nitric acid. Lime readily absorbs carbonic acid, the presence of which is detected by effervescence with acids. (This power of absorbing CO_2 has been utilized by Liebig to purify close rooms, for lime placed in them will, by such absorption, create a partial vacuum, to supply which air passes in through crevices. The same absorptive power partly causes the dampness of a new house, for the lime of mortar absorbs the carbonic acid of the air and the breath, leaving the moisture to condense on the walls.)

The *Liquor Calcis* of the Pharmacopœia is a solution in water containing about ½ gr. to the ounce (that being its point of saturation). It is prepared by digesting slaked lime in eighty times its weight of cold water for some hours, and is a colorless liquid when recently made, but on exposure to air, or if breathed into, an insoluble carbonate readily forms and precipitates. If warmed, the liquor calcis becomes turbid from deposition of some of the lime. It forms an ingredient in the black and the yellow "mercurial wash."

Liquor Calcis Saccharatus.—Saccharated lime-water is prepared by mixing slaked lime with twice its weight of sugar, and digesting in water for a few hours; it becomes yellowish by keeping; its taste is more caustic and unpleasant than that of the simple liquor; it contains 7.11 gr. of lime per ounce.

Linimentum Calcis is an emulsion or soap formed with equal parts of lime-water and olive oil, and containing an oleate of calcium.

CALCIS CARBONAS—CARBONATE OF LIME, $CaCO_3$, =100.

Three forms are officinal: (1) *Creta*—chalk—the native, friable, and not pure carbonate; (2) *Creta preparata*—prepared chalk—the same sub-

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stance well washed, or "elutriated," after being reduced to fine powder; and (3) *Calcis carbonas præcipitata*—precipitated carbonate of lime.

1. *Ordinary chalk* is used only to produce carbonic acid gas in the making of carbonates, etc.

2. *Prepared chalk* occurs either in white powder or in small conical masses. The process of "elutriation" consists in treating the powder with a large quantity of water, allowing it to stand for a time, decanting from heavy particles, and allowing the milky liquid to gradually deposit —this form is used in mistura cretæ and pulvis cretæ aromaticus.

3. *Precipitated* carbonate of lime is prepared by mixing a solution of carbonate of soda in excess, and at a boiling temperature, with solution of chloride of calcium. Carbonate of lime and chloride of sodium are formed, and the precipitate is washed until all the latter salt is removed. This preparation being crystalline and somewhat gritty, constitutes an ingredient of tooth powders, but is not otherwise recommended except in bismuth lozenges.

CALCII CHLORIDUM—CHLORIDE OF CALCIUM, $CaCl_2 6H_2O$, =219.

Preparation.—By neutralizing hydrochloric acid with chalk or white marble, and adding to the solution a little chlorinated lime and slaked lime. In the first process carbonic acid is evolved and chloride of calcium formed:

$$2HCl + CaCO_3 = CaCl_2 + CO_2 + H_2O.$$

In the second process the added lime frees the solution from iron and magnesia; it should then be filtered and evaporated to dryness at a temperature of 400° F. If the solution be simply evaporated, the chloride is left combined with water $CaCl_2 6(H_2O)$, and it is only at a heat sufficient to fuse the mass that it parts with all its water.

Characters and Tests.—This salt has a great absorbent power for water, is deliquescent, and very soluble; it occurs in crystals, or in whitish crystalline fragments of bitter, acrid, saline taste. It must be distinguished from *calx chlorata* (chloride of lime), and does not, like that compound, evolve chlorine on addition of hydrochloric acid.

CALX CHLORATA—CHLORIDE OF LIME—CHLORINATED LIME.

Preparation.—By saturating moist slaked lime with chlorine gas—$CaH_2O_2 + 2Cl = H_2O + CaOCl_2$—but as to its exact constitution there is still some difference of opinion. Many chemists, following Balard, consider it to be a mixture of chloride and hypochlorite of calcium, which would correspond to the above formula *doubled;* thus, $2CaOCl_2 = CaCl_2 + CaCl_2O_2$, and this, with the addition of two atoms of water, is the formula adopted by Garrod.

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CHARACTERS AND TESTS.—Occurs in whitish powder or lumps, having the odor of chlorine, and an acrid, caustic taste; if it contain much chloride of calcium it will be moist. It is unstable in composition, readily giving off chlorine when exposed to the air, and being decomposed by any acid. When pure it is wholly soluble in water, but it generally contains some free hydrate, and is only partially soluble. It has powerful deodorant and bleaching properties, which depend on the presence of chlorine, and the purity-test is directed to estimating the amount of this gas (chlorimetry). Thus, by adding hydrochloric acid to chlorinated lime, chlorine gas is liberated, and this being brought into contact with iodide of potassium sets free an equivalent amount of iodine, which is estimated by hyposulphite of sodium.

Liquor Calcis Chloratæ—Solution of Chlorinated Lime—contains about 13 gr. of available chlorine to each fluid ounce of water.

Vapor Chlori—Chlorine Inhalation.—Prepared by moistening 2 oz. of chlorinated lime with cold water in a suitable apparatus (*v.* p. 124).

CALCIS PHOSPHAS—PHOSPHATE OF LIME.

Officinal in two forms: (1) *os ustum*—bone-ash; (2) *pure tribasic phosphate.*

PREPARATION.—(1) *Os Ustum.*—When bones are calcined in *close* vessels, the residue consists of earthy salts mixed with charcoal (carbo animalis); but when calcined in *open* vessels, all animal and carbonaceous matter is burnt off, and the white friable residue consists mainly of phosphate and carbonate of lime (bone-earth, bone-ash). This, when treated with hydrochloric acid, and afterward with ammonia, is changed into (2) *tribasic* (or tricalcic) *phosphate*, $Ca_3 2(PO_4)$, which is washed and dried at 212°, and forms a crystalline white powder, insoluble in water, soluble in acids. It has been found to contain lead (Duquesnel).

This form is the one most commonly found in nature, sometimes almost pure (phosphorite) or in friable masses, like chalk (osteoliths), or in the fossil fæces of ancient saurians (coprolites), in shells and sedimentary earths. From the soil it is absorbed by plants, by the help of water and carbonic acid, and is determined specially to the *seed.* From plants it is received by herbivorous animals, and in *their* flesh and blood and bone it is sought by the carnivora. It has been said that the amount of phosphate of lime found in different animals is proportionate to the *activity of their movements* (Dusart and Blache). (The salt was obtained formerly for medical use from the excrement of dogs when hard and white, as it is passed after they have eaten many *bones;* it was known as "album græcum.")

Besides the tribasic phosphate there are two others, a *neutral* and an *acid phosphate.* The former, $Ca_3 H_3 2(PO_4)$, is a white, crystalline pow-

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der, tasteless and insoluble; it occurs in some (carbonated) mineral waters, and may be prepared by mixing neutral phosphate of soda with chloride of calcium. The *acid phosphate*, $CaH_4 2(PO_4)$, is very soluble, and even deliquescent, and is left in solution when sulphate of lime is precipitated after treating bone-ash with sulphuric acid.

Absorption and Elimination.—The various salts of lime differ somewhat as to their absorption and their action. The *tribasic* and *neutral phosphates*, in small doses (less than 5 or 6 gr.), with but little water, are wholly absorbed under the influence of the acid gastric secretion; but if given with much water, the acids are so far diluted that they do not act upon the insoluble drug, and it passes off mainly by the fæces. If large doses be given, the greater part passes out unchanged.

Gouriet has suggested that the solubility necessary for securing the absorption of lime phosphate is effected partly by means of the phosphate of soda contained in the saliva, partly by the phosphate of ammonia and the acids in the gastric juice; when it has passed into the veins, solubility is still further assisted by the carbonic acid present in venous blood. During respiratory combustion, when carbonic acid is given off and lactic and other acids altered, the phosphate that has been taken is only retained in solution by the help of the normal alkaline phosphates of the blood: if these be in small proportion the lime salts become soon deposited (more in bone than in other tissues), and little passes in the urine; if, however, in any given case the alkaline phosphates be in excess, then most of the lime salt is retained in solution in the blood until it is (mainly) excreted through the kidneys (*Lancet*, ii., 1860, p. 251). This explanation seems rather too chemical, and it must be compared with the important observations more recently made by Paquelin and Jolly. They conclude that the tribasic phosphate of lime is not acted upon in the stomach, unless it be by part becoming super-phosphate, and this again is precipitated in the intestine under the influence of alkaline biliary and pancreatic secretions, as *insoluble phosphate;* it is not capable of absorption, except in very small quantities; the circulation conveys very little, and the tissues, except bones, contain only traces; the bile has rather more. A certain amount of lime must enter the system from the food, and does so mostly as carbonate, which becomes changed and prepared for absorption by contact with alkaline phosphates and gastric acids, but *artificial phosphates* are eliminated almost entirely unchanged, only some of the acid being absorbed. Hence they conclude that the *addition* of such compounds to the food is rather an *obstacle to nutrition*, and that even the soluble acid preparations (lacto-phosphates, etc.) act only as acid principles, and pass out of the system as phosphates of another base. The lime phosphate contained in urine and phosphatic calculi, even when primary, is said to be almost entirely formed within the bladder. These views, as they are not quite in accordance with com-

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monly received clinical evidence, seem to require confirmation, but they suggest *moderate* expectation of cure by lime salts.

The bicarbonate, as occurring in carrara water, is soluble by virtue of the excess of carbonic acid, and readily absorbed. *The neutral carbonate*, in small doses (5 or 6 gr.), is soluble in the gastric juice, and is absorbed as a *chloride*. The *chloride* itself, in similar doses, and diluted sufficiently to disguise its caustic taste (as with 3 oz. of sugared water), becomes absorbed without gastric disturbance; but larger doses are apt to cause a sense of oppression, with nausea and diarrhœa. Unduly large doses of lime-water, or of phosphates or carbonates, may also cause gastro-intestinal irritation.

Of that which is absorbed, an equivalent quantity is eliminated, except during the period of growth, and especially of bone-development. There seems to be a power of laying-by some of the substance for this purpose, for, *e.g.*, during the early months of pregnancy, bony growths (osteophytes) sometimes form in the bone of the parent, which diminish with the growth of the fœtus. The eliminated portion is found in the urine, as acid phosphate, and in many other secretions, such as the pancreatic juice, and the semen; some may be detected also in plastic exudations; sometimes it forms calculi. It is often deposited in tumors, fatty, fibrous, and sarcomatous, and in old inflammatory exudations, as in tubercle of lung and strumous glands. About 45 gr. are daily eliminated by an adult man (Husemann).

Physiological Action (External).—Lime unslaked, or "quick," decomposes and destroys organic matter, and is used sometimes as a caustic, more often as a disinfectant, *e.g.*, in dissecting rooms and in graveyards; its affinity for water, and its ready combination with sulphur (as in sulphuretted hydrogen), will explain its good effects. It is used by tanners to remove the hair from hides, and by farmers as a fertilizing agent. Its action upon the living skin is irritant and to some extent caustic, but, as it has less "diffusion power," is more superficial and more limited than that of the alkalies proper—potash and soda. On the mucous membranes, however, its effects may be very severe, as when by accident it enters the eye, or when too strong a solution of it, or of its haloid salts, is taken into the mouth. Local inflammation and ulceration may follow, and even a fatal result be produced when the stomach is affected.

Weak solutions or the neutral salts, carbonate and phosphate, in powder, have a local astringent and sedative effect. The "lime-water" of the Pharmacopœia is not strong enough to be *caustic*, but controls secretion, especially from mucous membranes, and renders any tissues pale and dry.

Physiological Action (Internal).—*Digestive System.*—Lime-water and lime carbonates, when taken internally in moderate doses, produce

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similar local astringent and sedative effects, and act also as absorbents and antacids. The phosphate is a mechanical astringent to some extent. but the sulphate may alternately confine and relax the bowels, according to the irritation produced.

Circulatory System.—No effect upon this system is commonly traced to lime compounds, but full doses of the chloride are said to produce sometimes the symptoms of a "muscular poison" like potash, with lowering of temperature, slowing of pulse, and arrest of heart-action (Rabuteau and others: *Comptes Rendus*, February 10, 1873).

Nutrition.—The most interesting point in the physiological action of lime salts is their influence on nutrition, the necessity of phosphate for healthy growth, whether vegetable or animal, being especially evident. Experiments with plants have shown that the phosphates are in close relation with the nitrogenous elements. If, for instance, the nitrogenous husk or coating of a seed be removed, the phosphates are removed with it, and in the starchy part of the grain none are found. In the leaves they occur in the parenchyma, not in the nervules, and generally are most abundant in the cellular parts of vegetables wherein nutrition and reproduction are most active (Liebig). Wheat, planted in earth containing phosphates, germinates and thrives, but if all phosphate of lime be removed, it germinates, indeed, but soon dies. Peas (which contain a larger proportion of azotized matter), when similarly treated, germinate and even bear a crop, but if this crop be sown in a soil without phosphates, it does not flower (Georges Ville: *Conférences*, Paris, 1865, Rabuteau). That the improvement in nutrition is not due to the presence or absence of *phosphorus* as such, but to phosphate of lime, is shown by experiments on birds. Wheat contains a large quantity of *phosphate of potash*, and when pigeons are fed upon this alone, and are prevented from getting any carbonate or other salts of *lime*, they waste away, and their bones become weak and brittle. If, on the other hand, they can obtain lime in any form, it becomes changed into a chloride during digestion, and combining with the alkaline phosphates of wheat, provides them with lime phosphates, and secures or favors their due nutrition (Chossat).

There is also evidence that lime phosphates serve especially to nourish cartilage, bone, tendon, and muscle, so that they have been fairly called "restorative or analeptic tonics" to the *locomotor* organs, as iron is to the blood, or phosphorus to the nerve-tissue. Thus, as the result of observations on the reproduction of the shell in crabs, Schmidt found that a combination of phosphate of lime and albuminous material was most favorable for the formation of osteoid cells; phosphate was required for the first growth, though carbonate was formed later. Mr. Bridgman noted the formation of "artificial cartilage" by the passage of an electrical current through a viscous solution of carbonate of lime (Hughes Bennett: *Lancet*, i., 1863, p. 5). Beneke found that phosphate of lime was

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specially abundant in plastic exudations and wherever new growth was going on, and he adopted the microscope as a ready means of its detection—for if a drop of sulphuric acid be added to the liquid, crystals of lime sulphate are very quickly formed (*Lancet*, i., 1851, p. 432). The organism can assimilate phosphate of lime either in the soluble acid form (for the liquids and soft tissues), or to some extent in the basic insoluble form (for the skeleton); but its effects are produced slowly, and without the evident stimulation which we associate with the action of wine, iron, or quinine, so that we describe such lime compounds rather as restoratives than as general tonics, and as *modifying* rather than *stimulating* nutrition. (As a readily noticed, though slight evidence, of the effect of lime phosphates on nutrition, Rabuteau notes that white spots on the nails often disappear under their use.)

Besides their effects on ossification, etc., M. Mouriès, a distinguished chemist, has described a special effect of lime salts upon "irritability," or vital organic changes, so that if these salts are *absent*, assimilation and nutrition do not go on, and emaciation and death ensue, while if they are simply *deficient*, various degrees of lymphatic and osseous disease are produced. He has calculated especially that the food of those who live in towns is deficient in these principles, and that while every one ought to have at least 90 gr. daily, many, women especially, receive only about half that quantity; hence a secretion of poor milk and consequent weakly children, and he claims that by the use of a certain food containing lime phosphate with albumen, the proportion of still-born and of rachitic children in many families has been markedly reduced (quoted by Trousseau).

Any difference in the amount of urea and carbonic acid excreted under the influence of phosphate of lime is not exactly ascertained. The chloride of calcium is said to increase the amount of urine (Giacomini); and it is probable that like other chlorides it increases the excretion of urea (Rabuteau).

Lime in Potable Waters.—Waters that do not contain lime are flat and insipid, while a proportion of from 7 to even 20 gr. of carbonate in the gallon is compatible with their being good, wholesome, and pleasant (Parkes); such waters may be rendered sufficiently "soft" by boiling. Hardness dependent upon a soluble bicarbonate of lime is best treated by Clark's process, of adding slaked lime, which precipitates an insoluble carbonate.

Lime sulphate is contained in water from selenitic rocks, and a proportion of from 6 to 21 gr. per gallon must be considered unwholesome; it is liable to irritate the bowels, causing alternately diarrhœa and constipation, as was verified, especially in some prisons and hospitals of Paris, by Parent Duchatelet; such water is not much softened by boiling.

Nitrate of lime is sometimes found in drinking water, being derived probably from organic sources; it is likely to cause diarrhœa.

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Water from *magnesian limestone*, containing magnesia with some carbonate, and 4 to 12 gr. per gallon of *sulphate* of lime, has been considered specially likely to cause *goître;* but professional opinion, though still divided on this question, is now more inclined to the negative view.

Dr. McClelland (in an able report on the medical topography of Bengal) certainly gave remarkable instances from many villages scattered over a large district where the inhabitants, though living close together, were affected with goître or not, according as to whether they drank or not of certain wells, to which they were restricted according to caste; and he found that the wells used by goîtrous persons contained up to 25 per cent. *carbonate* of lime (Abstract in *British and Foreign Review*, 1861, i., p. 42; and Watson's "Practice of Physic," vol. i., 3d ed.); the presence of magnesia is not mentioned. Dr. Inglis, in his treatise on the subject, Dr. Coindet, of Geneva, and other authorities, have agreed in blaming lime-waters mainly for the production of goître, and its greater prevalence along ranges of lime-rock, as in Nottinghamshire, Derbyshire, and in parts of South America, are quoted in favor of the same view. Some connection has been further traced between this cause and *cretinism*, as well as goître; and Kölliker and others maintain, not without the support of post-mortem evidence, that by the habitual use of such lime compounds ossification is increased at *the base of the skull*, so that the cranial foramina become narrowed, and the supply of blood to the brain lessened (*British and Foreign Review*, January, 1861, p. 46). On the other hand, Dr. Mitchell has published a careful report upon the "Nithsdale neck," prevalent in that part of the south of Scotland, and has shown that some other element than water must be concerned. It is true that many of the wells used contained from 4 to 14 gr. of carbonate in the gallon (with magnesia), but that limit is compatible with health, and several wells in the same district contained the same quantity, and even to 24 gr., without the production of any goître (*British and Foreign Review*, April, 1862).

Synergists.—Alkaline and earthy bases have a similar absorbent action to that of the *carbonate of lime*, and reconstituents generally, such as iron and cod-liver oil, are adjuvants to the lime phosphates; aromatics also are often well combined.

Antagonists and Incompatibles.—Mineral acids, laxatives, and irritants either decompose or neutralize the action of lime compounds, with the exception of *phosphoric acid*, which is sometimes used with the acid phosphate, to render it more soluble.

Saccharated lime is said to be a specially good antidote to *carbolic acid*, and the following is Ferraud's formula:—℞. Sugar 15 parts, water 40 parts; dissolve, and mix thoroughly with quick-lime 5 parts (*Lancet*, i., 1876).

Hypochlorite of lime is an antidote for sulphuretted hydrogen.

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THERAPEUTICAL ACTION (EXTERNAL).—*Epithelioma.*—A mixture of quick-lime (2 parts) and caustic potash (1 part) is sometimes a useful escharotic for superficial forms of epithelial cancer; it should be mixed, just before using, with sufficient alcohol to form a paste ("Vienna paste"), and spread over a suitable aperture in diachylon plaster previously placed on the part; its action begins immediately, and lasts for about half an hour; the eschar is dark-colored, and separates in from ten to twelve days. A proportion of 6 parts of lime to 5 of potash is recommended by some authors, and for application to deeper-seated parts, such as the neck of the uterus, a combination of 1 part of lime with 2 of potash is used, especially by French surgeons ("caustique Filhos"); it is fused by heat, and poured into a small mould of lead, which can be cut away as the caustic is required.

Chronic Tonsillitis.—A mixture of equal parts of lime and caustic soda has been recommended under the name of "London paste" for occasional application to chronic conditions of enlarged tonsil (Mackenzie), but has not come into general use.

Onychia.—Prof. Vanzetti has recommended the application of caustic lime in preference to nitrate of lead for onychia maligna, and has reported two successful cases, in one of which the application was renewed several times, and in the other it was left in continuous contact (*Practitioner*, vol. xiii.).

As a *Depilatory* to remove superfluous hair, lime is sometimes used with arsenic (as in the Turkish "Rusma"), or in the form of a hydrated sulphide, prepared by passing hydrogen through a mixture containing 2 parts of lime with 3 parts of water: when saturated with the gas, this forms a greenish jelly, which is spread upon the part for a few minutes, and then removed with an ivory knife (Trousseau).

As a *Moxa*, or to produce an issue, a fragment of lime may be slaked on the skin by adding to it a few drops of water; much heat is produced, and the neighboring skin requires to be protected.

As a *Vapor Bath*, a piece of unslaked lime half the size of a man's closed hand is wrapped in a moist cloth, and this again in a dry one doubled several times, and fastened securely: and if one of these packets be placed on either side of a patient while in bed, the moist heat soon induces a copious perspiration lasting for one or two hours (Serre d'Alais: *Bulletin de Thérapeutique*, 1846). Dr. Hassall has recommended this as a ready means of establishing reaction in cholera, and others have used it in tetanus.

Hay-Fever.—In this malady the vapor evolved from lime chloride has been found serviceable, when the air of the patient's house is impregnated with it as far as possible; the solution should be used as a wash to the face and hands. It is reasonably presumed to act by destroying a fermentative or "germ" source of irritation to the mucous membranes (Elliotson).

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Croup and Diphtheria.—In the form of a warm, finely atomized spray, solutions of lime (1 in 30) have been much commended as chemical solvents of croupous membrane. Förster, Biermer, and others have shown that such membranes, and especially their fibrinous constituents, are soluble in lime-water (*Archiv der Heilkunde*, v., p. 522), but doubts have been expressed whether such an effect can be usefully and practically obtained in the living body. Biermer treated a true case of membranous croup (verified by rejection of membrane) by means of a warm lime-spray, and although the patient was in great peril, he obtained relief and finally recovered;—this physician, however, generally gave calomel at the same time (*British and Foreign Review*, July, 1865). Kuchenmeister has recorded several good cases treated successfully by the spray (*Bulletin Gén.*, April, 1865), and the experience of Steiner proved that diphtheritic layers on the fauces were dissolved by it in a marked manner: subsequently, however, the growths formed again, and could not be controlled by the remedy (*Jahrb. für Kinderheilk.*, 1870). Beigel has reported good results with it in croup, and Geiger, of Philadelphia, in diphtheria (*Practitioner*, i., p. 101); but Senator has more recently written against its employment, even from a theoretical point of view, and doubts its power of dissolving membranes "in situ." Gottstein and others consider the direct application of lime-water to the larynx by means of a brush to be more advantageous than the spray, and Albers, of Berlin, in desperate cases has injected the solution into the larynx from below, passing his syringe between the tracheal rings: cough was caused, and shreds of membrane were ejected (*Berlin. Klin. Woch.*, February 1, 1869; Ranking, i., 1870). The experience of the profession is not yet such as to enable us to decide the real value of lime-water applied locally in the treatment of these affections, but my own results have not been largely in its favor. Mackenzie finds it useful "when the false membrane is not very thick" ("On Diphtheria," p. 69).

Lactic acid and carbonate of lithia act similarly, and even better, in dissolving croupous membranes; Kuchenmeister, however, still maintains the superiority of lime-water. Sanné recommends the saccharate.

Cancrum Oris—Ulcerations.—Applied in substance or in solution, the chloride of lime is a valuable antiseptic and stimulant to fetid discharging surfaces. In cancrum oris, a little of the dry powder may be applied by the finger, and washed away immediately afterward, and in unhealthy ulcerations about the gums in general, and in salivation, a wash may be used containing 2 dr. to the pint of water, with glycerin, or ordinary lime-water may be used with nearly equal benefit.

A proportion of 1 to 10 or 15 of water has been found extremely useful, applied as a compress in cases of ruptured perineum, when the torn surface is apt to discharge offensively, and in unhealthy and indolent ulcerations of any part, the same remedy, or even ordinary lime-water, will

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diminish discharge, cleanse the surface, and promote a healthy action. Chloride of lime lotions are also good in erysipelas.

Skin Diseases.—In pustular and erythematous skin diseases, preparations of lime are often very useful. In *chronic acne*, I have often ordered lime-water, mixed with an equal part of rose-water, and applied three or four times daily with the best results. In *ecthyma*, it is commended by Mr. Wilson, and in the discharging stages of *eczema* and *impetigo*, it makes a useful lotion. In impetigo capitis, and in fissured nipples, lime-water mixed with oil is good. In chronic eczematous and scrofulous disease, lime salts are often useful when given *internally* (Tilbury Fox speaks well of "saccharated wheat phosphate" in such conditions). Cazenave thought the chloride good in lupus. In *carbuncles* and *boils*, a compress soaked in lime-water and covered with oiled silk, often acts beneficially; it checks inflammation, soothes pain, and promotes suppuration more quickly than ordinary poultices. In *erythema* and the *pruritus* of reddened and irritable skin, lime-water has a sedative, moderately constringing effect, and may be used either alone, or as a vehicle for other similar remedies. In *pruritus pudendi* it is often useful when applied freely and tepid, and in *osmidrosis* it will relieve the unpleasant secretion from the sweat-glands. Dusting powders containing precipitated carbonate of lime are used for *erysipelas* and *erythema*, and in cases of much sebaceous secretion, especially about the face. Combined with lard as "chalk-ointment" it is often a good application for indolent and irritable sores. In *tinea capitis*, after thorough cleansing, lime-water may be brushed in, but as a rule stronger remedies are necessary: a lotion of chloride is more satisfactory. In *scabies*, a strength of 1 oz. of chloride to 1 pint of water has been found sufficient to cure, but a more dependable preparation is made by boiling together 1 part of quick-lime and 2 of sulphur with 10 of water; this should be constantly stirred till well mixed, and then the liquid poured off for use; it is too strong to be rubbed in like sulphur ointment, but should be applied lightly with a brush, and afterward removed with a warm sponge, if necessary (*Lancet*, i., 1865). Pharmaceutists now commonly make such a preparation under the name of liquor calcis c. sulphure (vol. i., p. 33).

Burns and Scalds.—Lime-water, mixed with an equal part of linseed-oil (Carron-oil), or better, of olive-oil, was long since commended by Boyle and by Velpeau as a suitable dressing for the early stages of burns in every degree, and, though rather unpleasant, it has come into general use. It may be applied on carded cotton, and if the skin be unbroken, resolution of inflammation is promoted by it, and if suppuration occur, the liniment controls it, and hastens cicatrization. It relieves pain and inflammation in cases of wasp and other stings (Dauverne).

In severe cases of *Small-pox*, Dr. Joseph Bell recommended the same liniment to be applied to the face on cotton wool, carefully arranged to

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cover the affected part, but leaving apertures for the eyes, nose, and mouth. The wool should be fastened with another covering or with tape, so as to prevent admission of air, and by this means pitting may be prevented or decidedly lessened. An improved formula is a saturated sucrate of lime, made with lime, sugar, water, and glycerin; it forms a cool, drying varnish, and for burns may be diluted with oil, or ether may be added (*Pharmaceutical Journal*, October, 1873).

Chronic Discharges.—In chronic mucous and purulent discharges, lotions and injections of lime-water exert a most beneficial influence, as may be observed in chronic urethritis and in leucorrhœa, syphilitic or otherwise; in the former, a combination with mercurial oxides, such as the "black or yellow wash," is still more potent, and is in daily use for all forms of syphilitic ulceration.

The profuse nasal discharge, so usual in scarlatina and also mucopurulent otorrhœa, may be well and safely treated by washing out the affected parts with a tepid injection of milk and lime-water three or four times daily: over the affected ear a compress of lime-water, worn at night, is often advantageous. In chronic purulent ophthalmia a lotion containing chloride of lime is effective.

Ascarides.—Rectal injection of a few ounces of lime-water several times repeated is effectual in curing ascarides, and Dr. Price, of Margate, and Kuchenmeister have reported some successful instances of this treatment (*Lancet*, i., 1864); it has long been a favorite prescription of mine.

Therapeutical Action (Internal).—Lime-water was formerly much esteemed as an internal medicine, and was given not only as an antacid and astringent, but also as an antiseptic, and especially as a lithontriptic or solvent of calculi. It was not unfrequently given in excess, and produced irritant effects, but its use now is more restricted, and the doses given are smaller and more diluted.

Dyspepsia—Vomiting.—When digestion is accompanied with discomfort and oppression, or with acidity, pyrosis, and flatulence, especially if there be a tendency to diarrhœa, and to acidity of urine, lime-water and the carbonate of lime are often more serviceable than alkalies, because they are not only antacid but astringent. I have found them specially useful in the dyspepsia of chlorotic women, marked by the above symptoms, and generally by craving for acids and dislike to animal food. When flatulent distension affects the lower bowel, lime-water has been used in enema as absorbent of carbonic and other gases. Dr. Habershon has recommended the carbolate of lime in such conditions (*Lancet*, i., 1868). For cases of acid dyspepsia, when flatulent distension is not so prominent a symptom, but when there are heartburn and pain with evidence of gastric congestion, the bicarbonate of lime, dissolved with an excess of carbonic acid in the slightly effervescent form known as carrara water, is very useful, for it is less nauseous to some patients,

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and more easily tolerated than lime-water, so that more of it may be given at a time; it may be mixed with an *equal* part of milk, while of lime-water not more than *one-eighth* part should be used.

For the special symptom of nausea and vomiting from irritative gastric conditions, milk and lime-water is a simple and often effective treatment; given frequently in small quantities, iced, it provides digestible nourishment which is sometimes better retained than any other. It is valuable in the vomiting of pregnancy, and even in that of gastric ulcer, in which latter malady only a dessertspoonful in a wineglassful of milk should be tried at a time. The lime acts partly as a sedative to the mucous membranes, partly as an antacid, and partly mechanically by breaking up the curd of milk; hence it is particularly useful as an addition to cow's milk for children brought up by hand, only in any case where constipation is marked, soda-water may be substituted for a time.

Mr. Metcalfe Johnson has written highly of the value of hydrated *phosphate* of lime in the sickness of pregnancy; and Dr. Leared of the chloride (½ dr. to 1 dr. liq. calcis chloridi) in sarcinous vomiting. Dr. Cleland specially recommends the saccharate as a better antacid than magnesia, and useful in dyspepsia dependent on either too little or too great secretion of gastric juice; it does not constipate like other lime compounds; it may, however, cause nausea if taken on an empty stomach (*Edinburgh Medical Journal*, 1859).

Carrara water is suitable for taking with wine at the later meals, and several other natural mineral waters containing lime are of acknowledged value in gouty and acid forms of dyspepsia generally (vol. i., p. 173): Seltzer contains 3 gr. of carbonate in the pint, Pyrmont 4, Kreuzbrunnen 4.13 with much carbonic acid, Wildungen 5.4 to 9.7, and Pouges (a Spa between Paris and Lyons) contains as much as 12 gr., and is of great repute. Dr. Basham found such waters especially suitable for hypochondriacal, but not for anæmic cases.

Intestinal Catarrh—Diarrhœa.—Lime-water and lime carbonate are useful in these conditions, especially if gastro-intestinal acidity be present, as it usually is in young children; the breath is then offensive, the motions frequent, loose, greenish, sour-smelling, and deficient in bile; the abdomen is distended, cramping pain occurs at intervals with drawing-up of legs, and there is often sickness. Restriction to milk and broth diet, with the addition of 1 or 2-gr. doses of carbonate of lime, will often cure this disorder; in the diarrhœa of dentition as well as in the more chronic forms connected with strumous or mesenteric disease, such treatment is specially indicated. (Castor-oil may be required at first to remove any cause of direct irritation such as undigested food, mucus, etc., and the use of insoluble lime salts should not be prolonged more than necessary, otherwise irritation or some degree of obstruction may be caused.)

In *chronic diarrhœa* dependent upon relaxed condition of the ali-

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mentary canal, and also when kept up by ulceration of the bowel, I have used lime preparations with the best possible effect. Bretonneau recommended them in enema for these cases.

In the *diarrhœa of enteric fever*, and of *tuberculosis*, milk and lime-water may prove of great, if only temporary service, but should not be used in large quantity if hemorrhage or symptoms of acute inflammation be present. The alkaline earth is plausibly supposed to combine with the secretions of the ulcerations and to form a layer which protects the terminations of sensitive nerves against contact with the contents of the bowels. Mialhe especially applied this explanation to the phosphate of lime, which salt has been much used in the treatment of diarrhœa and of acidity, and owing partly to its phosphoric element, is considered to exert a special restorative power: according to him, if given with bread and sugar it becomes changed by the slight acid of the former and by the gastric acids into a soluble acid salt, which does not itself coagulate albuminoid material, but when brought into contact with a small proportion of alkali, becomes converted into an insoluble basic phosphate of gelatinous character, which protects the mucous membrane, and checks diarrhœa.

This salt was the principal ingredient in the "white decoction" of Sydenham. The quinovate of lime is specially commended by Kerner (*v.* "Vegetable Kingdom").

Aphthous Conditions of the mouth and alimentary tract, when occurring in infants, with green but not necessarily liquid stools, may often be cured by lime-water or prepared chalk.

Bone Disease—Fractures.—Piorry furnishes evidence of the value of phosphates in osteo-malacia, or softening of the bones generally, also in spinal caries or "Pott's disease" (*Gazette des Hôpitaux*, 1856), and I have certainly seen them very beneficial in cases of caries and joint disease. Reasoning from the observation that birds with a broken limb lay eggs without shell during the process of repair, Dr. Fletcher was led to administer a mixture of calcined bone, prepared chalk, and lime-water in cases of fracture (in man), and reported several cases of very early union of long bones (*Lancet*, 1846). Milne Edwards made similar observations on dogs and rabbits, producing fractures as nearly as possible alike, and then finding that the animals who got lime phosphate recovered more rapidly than the others; and M. Gosselin found the same results in men (*Comptes Rendus*, xiii., p. 631; and *British and Foreign Review*, July, 1856): on the other hand, it has been pointed out that in fractures of old persons, in whom the bones are brittle, lime salts are better avoided. They have been strongly recommended during pregnancy and lactation in enfeebled mothers, both to relieve their neuralgia, debility, and dyspepsia, and also to favor the development of healthy non-rachitic children (*Der Prakt. Arzt*, May, 1869); and I have for years recommended their use in back-

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ward dentition, delayed power of walking, and retarded closure of the fontanelles. These are usual signs of a rachitic tendency, and in the fully-developed malady of rachitis, saccharated lime is strongly to be recommended. It is true that although parts of the bones become softened in this disease, and are deficient in lime, often at the same time, lime phosphates are largely excreted in the urine, so that the fault is one rather of mal-assimilation than of actual deficiency, yet I agree with Dr. Ringer that the administration of lime, and especially of lime-phosphate, "appears to control this defective and perverse nutrition, and to induce healthy growth, so as to favor consolidation of the skeleton and improve the condition of soft parts," and that practically they are extremely valuable, though not always alone curative. He compares this use of it to that of iron in anæmia, where the fault is equally one of want of assimilation rather than of quantity. As already mentioned under the physiological action of lime (*v.* p. 99), it has been objected that it is so little soluble that quite sufficient may be introduced with ordinary food, and that to give it in medicine rather interferes than otherwise with normal nutrition (Paquelin and Jolly); but practically we do not find it so. Considering, however, the evident insolubility of ordinary tribasic phosphate, M. Dusart and others have introduced acid solutions—lacto-phosphates—which have come much into vogue, and are sometimes very suitable, but it must be remembered that often in unhealthy rachitic children most of the secretions are already too acid, and need rather to be neutralized by a basic earthy salt, and any excess of acid would tend rather to dissolve osseous salts, and cause them to be eliminated, not deposited. It may often be better to give the ordinary salt (phosphate) recently prepared, if possible, and with flour or milk, and to trust the stomach to absorb what is needed, and the surplus will pass through the intestine, not injuriously. The combination of lime phosphate with sodium chloride (calcaria phosphorica salita) has been found very soluble (Sabellin, Dorogow, Husemann, p. 724). The *sulpho-carbolates* of lime have been specially recommended in rickets, but Dr. C. Ritchie did not find them serviceable (*Medical Times*, i., 1871).

There is reason to think that natural salts of lime, such as have recently passed through *organic* structures, are preferable to such as have been deposited as *mineral*. Thus, Piorry recommended, in bone-softening and spinal curvature, fine filings of fresh bone, 1 oz., to be taken in milk or rice-milk, and found it succeed when proper light, warmth, and food had failed (*Gazette des Hôpitaux*, 1856, No. 139; *Medical Times*, i., 1857).

Others have derived medicinal phosphates from the *vegetable* kingdom. Thus Dr. Hake and Dr. Tilbury Fox recommend a strong decoction of good bran to be made and evaporated, and the residue mixed with sugar; and a preparation of this kind known as "saccharated wheat phos-

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phates" has come largely into use for mal-nutrition, rickets, etc. (*Medical Times*, i., 1866). It may be desirable to state again that the advantage of lime salts in bone disease is not traced simply to chemical and physical processes, but also to direct improvement of digestion, absorption, and nutrition.

Struma—Glandular Disease.—Lime-water was long since commended for the treatment of suppurating glands, and of ulcerations, as well internally as locally (Shapter, Pereira). The phosphate was especially found serviceable, though not always curative, in the different manifestations of scrofula, by Beneke (*Lancet*, 1851), and by Stone (*New Orleans Medical Journal*, and *Bulletin Gén.*, 1852, t. xlii., p. 229); while Beddoes, Fourcroy, A. T. Thomson, and more lately Dr. W. Begbie, have reported very good results from the chloride. Dr. Beddoes collected upward of one hundred cases, including many of so-called "tabes mesenterica," and Dr. Begbie has corroborated the good results to be obtained from doses of 10 to 20 gr. daily. He records also good cases of the subsidence of enlarged parotid and lymphatic glands under the same medicine, when iodine and cod-liver oil had failed to cure (*Edinburgh Medical Journal*, July, 1872). It must be stated, however, that in the experience of most other observers, these latter remedies have superseded lime salts, and that Mr. Benjamin Phillips and other writers on scrofula have expressed themselves much less favorably concerning them.

Of late years, a mineral water in the West Indies has obtained great repute in the treatment of glandular enlargements, and has been found to contain calcium chloride, though in small proportion. The "Bridge of Allan" waters contain it, and have a purgative effect in consequence. I have myself given the chloride a fair trial in 1 to 5-gr. doses twice daily for lymphatic disease in children, and have sometimes seen good results from it when persevered with; though, as a rule, I prefer the carbonate to other lime compounds.

The use of sulphide of calcium in strumous and scrofulous sores and enlarged glands, and in localized suppurations of any kind, will be found fully discussed under sulphur.

Anæmia.—In anæmia and debility, the consequence of overwork, of close confinement, etc., Dr. Ringer speaks highly of the phosphate of lime, especially when combined with the carbonate and with iron.

Chorea.—Rodolfi has recorded cases of chorea treated by lime chloride, 7 to 15 gr. in twenty-four hours, and finds it suitable for all cases provided that there is no "cerebral hyperæmia;" improvement began at once, and cure resulted in about sixteen days (*Medical Times*, i., 1869). Aperients were also given, and, as Jaccoud remarks, belladonna was combined with the lime, so the results must be held doubtful.

In nerve-disorder with sleeplessness, and in infantile convulsion, Dr. Hammond has found the *bromide* of calcium more readily taken and

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more effective than that of potassium, and I can to some extent verify his observations.

Phthisis—Chronic Bronchitis.—In the early stages of phthisical anæmia and debility, especially in excitable florid persons with tendency to headache and dyspepsia, also when in later stages profuse sweating, or expectoration, or diarrhœa is present, or when the menses are frequent or profuse, the carbonate or phosphates of lime often exert a good influence in lessening such discharges and in improving strength; even when actual softening has occurred and cavities formed, I have given these salts with the object of assisting cretaceous degeneration, and often with benefit. Lime well supplements cod-liver oil, and the two remedies may be suitably combined, since they form an emulsion readily taken by children—1½ parts of lime-water to 1 of cod-liver oil is perhaps the best proportion (*Medical Times*, i., 1862, p. 399). Van den Corput, a Belgian physician, though praising this combination, recommends rather the chloride flavored with anise or such proportions of lime-water, etc., as will make a solid jelly ("jecoro-calcaire savon"), which is still better taken (*Medical Times*, ii., 1870, p. 624); it has not, however, come much into use in this country. Cod-liver oil does not mix well with syrup of lacto-phosphates, and is liable to become rancid when in contact with it. At a hospital in Moscow excellent results were obtained in the treatment of phthisis by freshly calcined bone.

The hypophosphites of lime were introduced as the best compound for the treatment of phthisis, owing their value in part to the base, and in part to the hypophosphorous acid contained. The rather extravagant praise which was bestowed upon them has not been supported by the majority of the profession, and opinions are still divided as to their real powers. I believe myself that they are sometimes of much service. Rabuteau remarks that as hypophosphites raise animal temperature, the phosphates would seem more rational remedies for phthisis; that dogs never have phthisis (?), probably because they eat so much bone; also that phosphates are commonly in excess in the urine of the phthisical, and therefore to supply them artificially is reasonable. Charters has lately published illustrations of their value in night-sweats (*Lancet*, i., 1876), and Gugot has made a similar observation (Husemann). Mr. Pidduck specially praises the iodide of calcium in struma and phthisis; it is tasteless, non-irritant, readily decomposed, but not readily producing iodism (*Medical Times*, i., 1858). Dr. Sawyer states that he has seen, in chronic phthisis, better results from calcium chloride than from other medicines, hypophosphites of lime and soda included. He recommends 10 gr. of the chloride with 1 dr. of water and of glycerin, to be taken in milk after meals, and finds this often "check night-sweats, increase weight, and dry up pulmonary lesion" (*British Medical Journal*, i., 1880).

In *chronic bronchitis*, I have frequently seen lime-water, and also car-

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bonate of lime, act well in diminishing profuse expectoration and troublesome cough; it should be given internally, and the lime-water applied locally by an atomizer.

In *Gangrene of the Lung*, Dr. Graves advised the chloride with opium.

Cancer.—Besides the local application of lime-water and lime chlorides to cancerous sores, a power has been claimed for these remedies taken internally to diminish malignant growths; thus, a curious case, in which an extensive mammary cancer separated and fell off after a prolonged use of lime carbonate, is recorded by Dr. Peter Hood (*Lancet*, ii., 1867, p. 454); the patient was advanced in years, and for a long time took the carbonate, as prepared from the inner side of oyster shells, 10 to 20 gr. twice daily. Another case, cured under the same remedy, is also mentioned.

(If the taking of lime salts have any power in inducing the cretification of tubercle—and there is some clinical evidence to that effect—and if they can diminish the blood-supply of a fibroid tumor and hasten cretaceous degeneration of it, as suggested by Mr. Spencer Wells, then it is not unreasonable to expect advantage from them in some cases of cancerous degeneration, but I am not aware of other evidence in this direction.)

Uterine Disorder—Menorrhagia—Fibroid Tumor.—There is a general consensus of opinion as to the power of lime salts to relieve uterine hemorrhage. Dr. Rigby published a marked case dependent on "fibrous tumor" (*Medical Times*, ii., 1854) treated by the chloride, and Dr. Rogers, Dr. Routh, and others have recorded similar experience; doses of 10 drops of the liquor calcis chloridi, increasing by degrees to 30 or 40 drops, and continued for some months, are recommended (Ranking, 1871; *Lancet*, 1873). In too early and too profuse menstruation, I have been accustomed for many years to prescribe the carbonate of lime with much success. Mr. Spencer Wells believes that the chloride acts by leading to atheroma of vessels, and hence is useful in lessening the growth of uterine fibroids, and may even cause their disappearance (*British Medical Journal*, i., 1868). Certainly, in some instances under my care, uterine and other tumors have diminished under treatment by carbonate and chloride of lime.

It is true, as remarked by Dr. Meadows, that large quantities have been given to many patients with uterine fibroid tumor without any result, and he ridicules the idea of any possible promotion of calcification by such means (*Lancet*, ii., 1873, p. 3): he argues that a natural process of atrophy may occur, and that calcarcous degeneration is only a consequence, not a cause of this. Dr. Meadows ridicules equally the idea of lime curing rachitis: but no reasoning from probabilities should prevent our appreciating clinical facts.

Uric Acid Deposits—Calculus.—In these maladies, lime has by no means retained the reputation it formerly held, but may certainly give

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some relief. The secret remedy of a Mrs. Stephens received so much commendation, that Parliament purchased the recipe for £5,000 about one hundred years ago, and it was found to be mainly of calcined egg-shells (lime carbonate) and soap, with vegetable bitters, and though much of the benefit must be set down to the alkali of the soap, yet Whytt obtained very good results afterward from simple lime-water. Lime salts may relieve vesical pain and inflammation, and by a constringing and sedative effect on the mucous membrane of the bladder may lessen the ropy discharge and the general sensibility; a solvent action may also be exerted, but not probably to a great degree; the benzoate of lime has been credited with more decided effect. Lime-water should also be injected, after washing out the viscus with soothing mucilaginous liquids. Professor Stillé remarks, "There is reason to believe that uric acid gravel may be dissolved and eliminated under the use of lime compounds. How far they are superior to the carbonates of the alkalies for this purpose will depend chiefly on the state of the digestive organs—when these are feeble, lime-water is the better preparation."

The waters of Wildungen, which are much used in lithiasis, owe their efficacy principally to lime carbonate (vol. i., p. 172).

Diabetes Mellitus.—Kissel reports two cases cured by lime-water, improvement being for several weeks very slow, but afterward rapid and marked. My own experience, however, has convinced me that this is inferior to many other remedies.

Albuminuria.—On account of the power of lime salts to dissolve organic membranes, they have been recommended in chronic Bright's disease, and in post-scarlatinal albuminuria "to dissolve proteinous infiltrations of the kidney." Kuchenmeister reports cases treated by large doses of lime-water and soluble lime salts, with immediate and marked increase in the quantity of urine passed, and with corresponding subsidence of the dropsy. The amount of albumen was lessened, but sometimes slight hemorrhage occurred (Ranking, 1869; *Rev. Méd.*, February, 1870). His results have not been widely corroborated, but Baudon reports a case in which the iodide of calcium seemed to succeed after iodide of potassium failed; quinine and iron were given also (*Practitioner*, i., 1869).

From our knowledge of the styptic properties of lime salts, we should rather expect them to restrain renal hemorrhage than to cause it, and Stromeyer and Caspari report the value of the phosphate for this purpose.

PREPARATIONS AND DOSE.—*Liquor calcis:* dose, ½ to 2 fl. oz. or more (contains ½ gr. to the ounce). *Liquor calcis saccharatus:* dose, 15 min. to 1 fl. dr. (contains 7.11 gr. to the ounce). *Linimentum calcis* (lime-water and olive-oil, equal parts). *Creta præparata:* dose, 10 to 60 gr. *Mistura cretæ:* dose, 1 to 2 fl. oz. (contains chalk ¼ oz., gum-acacia ¼ oz., syrup ½ oz., cinnamon water to 8 oz.). *Pulvis cretæ aromaticus:* dose,

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10 to 60 gr. (contains cinnamon, nutmeg, saffron, cloves, chalk, cardamoms, sugar). *Pulvis cretæ aromaticus c. opio:* dose, 10 to 60 gr. (contains 1 gr. of pulv. opii in 40).* *Calcii chloridum:* dose, 2 to 10 gr. *Vapor chlori* (made with chlorinated lime). *Calcis phosphas:* dose, 2 to 20 gr. or more. *Calcis hypophosphis:* dose, 2 to 10 gr. Besides these officinal preparations, there are many compounds such as the iodide, the bromide, and the carbolate of calcium of which the lime is the less active ingredient, and of which the properties are mainly those of iodine, bromine, etc. There are also many private preparations of lime, such as the lacto-phosphate, the compound syrup of the phosphates (Parrish), and others. A number of formulæ for lime sucrates, hypophosphites, etc., are given in the *Pharmaceutical Journal*, June, 1877.

The *sulphide of calcium* is not officinal: convenient granules of it containing $\frac{1}{10}$ gr. and up to 1 gr. are now prepared.

Various formulæ for "phosphated bread" and natural forms of phosphate have been published. Superphosphate of lime ½ oz., carbonate of iron ½ oz., butter and sugar, of each ¼ lb., flour ¾ lb., treacle ½ lb., make 80 cakes (*Medical Times*, i., 1859). Acid phosphate of lime and moist carbonate of soda may be used as a good "baking powder" (Horsford, Ranking, ii., 1860). Chevrier has an aërated water containing tribasic phosphate (*Pharmaceutical Journal*, September, 1874). Dannecy recommends to wash and powder beef bones, and boil them for an hour with carbonate of soda and water, then to wash in a filter—to dry and sieve (*Bulletin de Thérapeutique*, March 15, 1858).

[PREPARATIONS, U. S. P.—*Calcii carbonas præcipitata; Cretæ præparata; Mistura cretæ:* prepared chalk ½ troyounce, glycerin ½ fluid ounce, gum arabic 120 grains, cinnamon water, water, each 4 fluid ounces; *Trochisci cretæ:* prepared chalk 4 troyounces, gum arabic 1 troyounce, nutmeg 60 grains, sugar 6 troyounces, make 480 troches. *Calcii chloridum; Calcii hypophosphis; Calcii phosphas præcipitata; Calx; Liquor calcis*—lime-water; *Linimentum calcis:* lime-water 8 fluid ounces, flaxseed-oil 7 troyounces. *Calx chlorinata*—chlorinated lime.]

CERIUM, Ce,=141.

This metal, which is not a common one, was discovered by Berzelius, in a Swedish ore called cerite or heavy-stone—a silicate of iron, calcium, lanthanium, didymium, and cerium, which last is obtained from it in the form of a gray metallic powder: oxalic acid is used in the process, and hence oxalate of cerium is the best known commercial salt: it is the only one officinal.

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CERII OXALAS—OXALATE OF CERIUM, $Ce_2 3(C_2O_4)9H_2O$, =708.

PREPARATION.—By mixing a solution of any soluble salt of cerium (*e.g.*, the chloride) with solution of oxalate of ammonia—the oxalate of cerium precipitates.

CHARACTERS AND TESTS.—A white granular powder, which when heated to redness gives a reddish-brown residue of impure oxide, soluble in boiling hydrochloric acid without effervescence. This solution gives, with sulphate of potash, a white double sulphate of potassium and cerium: the oxalate itself is insoluble in water. The soluble salts, such as the chloride and nitrate, have a sweet astringent taste: with alkalies and their carbonates they give yellowish-white precipitates.

PHYSIOLOGICAL ACTION (INTERNAL).—There is some *clinical* evidence in favor of attributing to cerium a sedative action upon the gastric mucous membrane and upon the nervous system, and especially on reflex excitability, but I am not aware of any physiological research as to the properties of this drug.

SYNERGISTS.—Bismuth, silver, and cyanides.

THERAPEUTICAL ACTION (INTERNAL).— *Vomiting of Pregnancy, etc.*— Sir J. Simpson introduced the oxalate of cerium "as a sedative tonic resembling bismuth and silver," valuable in irritative dyspepsia and vomiting, especially when dependent on pregnancy (*Edinburgh Monthly Journal*, December, 1854; and *Medical Times*, i., 1855). Several years later he wrote strongly in favor of its especial and proved value in the last-mentioned condition and in sympathetic uterine vomiting generally. He calls it "the simplest and surest remedy," states that he has cured with it more cases than with any other single medicine, and records several illustrations of its prompt and effective action in obstinate cases which had resisted all ordinary treatment: he gave 1 to 2-gr. doses in pill (*Medical Times*, ii., 1859). Dr. C. Lee and Dr. W. Curran have recorded similar experience, but the latter rather confused his results by giving bromide and bark at the same time. Dr. C. K. Mills (U. S.) found that the nausea and vomiting of pregnancy almost always yielded promptly to a few doses: of eleven cases reported, ten were relieved permanently, one only for a time. Similar symptoms associated with dysmenorrhœa, flexion, and other uterine disorders, and with hysteria from anxiety, grief, overwork, and the like, were also relieved by cerium. Obstinate vomiting occurring in the course of phthisis, and during typhoid fever, was successfully treated by 2 to 3-gr. doses (*Medical Record*, March, 1876). The amount of published evidence as to the general use of the drug is meagre, but I have myself often obtained excellent results from it. Dr. Image, in a recent paper, attributes occasional disappointment to the use of too small doses: he recommends 10 gr. with tragacanth, tincture of orange,

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and water, every four hours, the first dose being taken half an hour before rising. He quotes a case in which vomiting always had commenced in the fourth week of pregnancy and lasted till the eighth month, but with this remedy the attacks, though recurring at intervals, were invariably checked in two or three days, and of a great many cases of pregnancy with vomiting, not a single one was unrelieved by the same treatment (*Practitioner*, June, 1878). He found it also efficacious in nausea from uterine irritation, and I have had similar experience on many occasions. I have not required to use so large a dose, but it should certainly be tried if smaller ones fail. Dr. Busey has lately recommended oxalate of cerium to obviate the nausea and headache produced in some persons by opium, just as Da Costa recommended bromide, and others coffee; it has the advantage of small bulk and of tastelessness (*Practitioner*, i., 1879, p. 214).

Dyspepsia—Gastrodynia, etc.—Simpson recommended the oxalate in primary as well as in reflex gastric disorder, and Dr. C. Lee has given instances of its value in pyrosis, in phthisical and atonic dyspepsia; it may be used in the class of cases in which bismuth is indicated. Dr. Mills found it act best when morbid sympathetic influences were a main cause of the indigestion, and depressed or deranged innervation of the stomach existed: in diarrhœa from nerve-irritation, cerium was also successful; "it seems to have the power of diminishing reflex excitability of the alimentary tract;" in dysentery, gastric ulcer, cancer, gastro-enteritis, he tried the medicine, but with less satisfactory result (*Medical Record*, March, 1876).

"*Chronic Cough.*"—Mr. Clark has recorded cases of chronic lung-disorder with some partial consolidation, and accompanied with dyspnœa on exertion and violent *morning cough* producing sickness, the symptoms were much relieved by the (apparently) sedative effect of oxalate of cerium, given in 5-gr. doses half an hour before rising (*Practitioner*, April, 1878).

Epilepsy.—Dr. Ramskill has recorded two cases of epilepsy preceded by a "gastric aura"—*i.e.*, "a sense of faintness, and of something turning upside down at the epigastrium"—which were benefited by the oxalate of cerium, when belladonna and bromides had failed to relieve. Cases of epilepsy without this aura were not benefited, and Dr. Ramskill suggests that in the gastric cases there was a primary failure of action in the splanchnic nerves, that the medicine acted as a sedative and conservator of their power, and that this influence being conveyed to the medulla lessened its excitability (*Medical Times*, i., 1862). The cerium salt has at least this advantage over nitrate of silver, that it will not darken the skin.

PREPARATION AND DOSE.—*Cerii oxalas:* dose, 1 to 5 gr. or more—according to Dr. Image, 10 gr. For an infant or child under two years, ¼ to ½ gr.

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[PREPARATION, U. S. P.—*Cerii oxalas.*]

ADULTERATIONS.—Mr. H. Greenish asserts that commercial oxalate of cerium contains a large proportion of the oxalates of lanthanium and didymium, and that the pharmacopœial test does not exclude their presence; this may possibly account for failure in some cases (*Medical Record*, 1877).

CUPRUM—COPPER, Cu,=63.4.

This metal (which has its name from Cyprus) is now obtained chiefly from the mines of Cornwall, of the Pyrenees, and of Fahlun in Sweden, in the form of a double sulphide with iron (copper pyrites, Cu_2S,Fe_2S_3): an oxide, a sub- or red oxide (cuprite), and an oxycarbonate (malachite), also occur, as well as arseniates, phosphates, etc.

The metal is extracted from the ores by a process of roasting and fusion; a purer form by electrolytic decomposition of the pure sulphate.

Brass is a compound of copper with zinc (but often contains some *lead*), and bronze is an alloy of copper, tin, and zinc: ordinary commercial copper may contain arsenic.

CHARACTERS AND TESTS.—Copper is the only red metal; it is lustrous, malleable, and ductile, of sp. gr. 8.92; unaltered in dry and cool air, in moist air it becomes coated with hydrated carbonate, and at a red heat is oxidized. In contact with acids, alkalies, or fats, it is readily acted on, with formation of various green compounds, acetates, or oxides, commonly known as verdigris. It is soluble in nitric acid, in sulphuric acid with heat, and in hydrochloric acid if air be present, also in ammonia. It forms cuprous and cupric salts.

Tests may be remembered by their color, as (1) *the red test*, shown by immersing clean iron in an acid solution of copper, when the red metal will be deposited; (2) *the blue test*, shown by the coloration produced with excess of ammonia; (3) *the brown test*, by the bulky reddish-brown precipitate which occurs with ferrocyanide of potassium (R. W. Smith).

CUPRI SULPHAS—SULPHATE OF COPPER—BLUE VITRIOL—COPPERAS, OR BLUE STONE, $CuSO_4,5H_2O,$=249.4.

PREPARATION.—By dissolving copper in sulphuric acid, with the aid of heat,

$$Cu+2H_2SO_4,=CuSO_4,+2H_2O,+SO_2,$$

treating the product with hot water, filtering, and crystallizing.

CHARACTERS AND TESTS.—Occurs in oblique prisms of deep blue color, and metallic styptic taste; soluble in 4 parts of cold, and 2 of boiling water, insoluble in alcohol, effloresceing slightly in dry air. The

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anhydrous salt is *white*, but turns *blue* when moistened with water, and hence serves as a test for the presence of water in absolute alcohol. The sulphate answers to the tests for copper already given, and like other sulphates, gives a white precipitate of sulphate of baryta with barium chloride.

Ammonio-Sulphàte of Copper in solution is used as a test for the presence of sulphides in liq. ammoniæ fort., and also as a test for arsenious acid, with which it produces a light-green precipitate of arsenite of copper (Scheele's green).

SUBACETATE OF COPPER—VERDIGRIS—ÆRUGO, $Cu(C_2H_3O_2)_2CuO$.

PREPARATION.—Manufactured by exposing copper plates to the action of pyroligneous acid.

CHARACTERS.—Occurs in powder, or lumps of small crystals, bluish-green in color, of sour odor, and metallic taste. A solution is officinal as a test for butyric acid in valerianate of zinc; the acid is precipitated by it.

ABSORPTION AND ELIMINATION.—Metallic copper, even when powdered, is not usually absorbed. Drouard gave large doses to animals, without any result (Paris, 1802), but when finely divided, some may be rendered soluble by the gastric acids, and traces may be detected in the urine and saliva (Mialhe, Mitscherlich, Portal). Copper coins have often been swallowed with impunity, but profuse salivation is recorded in the case of a child after swallowing a penny (Barton, quoted by Gubler). That the sulphate can be absorbed from wounds has been both affirmed and denied. Langenbeck and Städeler have traced poisonous symptoms to this cause only when fatty acids were present, but Blodig reported vomiting from a single application of cupric caustic to the conjunctiva: such absorption, though it may occur, is certainly not frequent (Husemann). Workers with alloys or salts of copper absorb it, for their secretions, hair, and teeth may be colored green by it during life; it has been found in their urine, and after death in the bones, and even in the earth in which they are buried (Millon: *Bulletin de l'Académie de Médecine*, t. xii.). Soluble salts of copper combine with albuminous secretions and form a bluish coagulum; this, when resulting from a salt of an organic acid (as the acetate) is still soluble, but from a salt of a mineral acid (as the sulphate) it is more resistent (Mitscherlich). In any case, only a portion of even a moderate dose is absorbed into the blood, and this probably as an albuminate—the larger portion passes off by the bowel, and appears in the dark brown fæces as sulphate.

Elimination occurs by the bile, the saliva, and bronchial secretion (Flandrin and Danger: *Annales de Thérapeutique*, vol. i.): these observers did not detect it in the urine, but others have done so. Elimina-

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tion is *slow*, for Orfila found copper in the viscera seventy days after its use had been omitted. It is apt to be deposited in the liver especially.

It must be recognized as a very usual constituent of the normal organism. Sargeaux detected it in the blood of many animals, and Odling and Taylor in the liver, kidneys, and other organs, irrespective of poisoning (*Guy's Reports*, 1866). In the bodies of domestic animals fed on vegetable food Wackenroder found no perceptible amount of copper, but in snails and shell-fish comparatively much; in man and carnivorous animals he found also a rather large proportion both of copper and lead, and concluded that they were derived from the nutritive or medicinal substances taken (Abstract in *British and Foreign Review*, 1855). Odling and Dupré found copper in bread, flour, shell-fish, etc., and in the human liver and kidneys, not invariably, but usually (*Guy's Reports*, 1858). Stevenson remarked that copper might be derived in the course of an analysis from a copper lamp used for incineration, so that the greatest care is required in such investigations (*Lancet*, ii., 1872). Schwartzenbach found 0.004 gramme of copper and rather more lead in 2,100 grammes of liver (*British and Foreign Review*, January, 1857); Orfila had reported ten times as much. More recently, the average amount found in the entire liver and kidneys in fourteen bodies was 2 to 3 milligr. ($\frac{1}{33}$ to $\frac{1}{22}$ gr.), and it was found also in the fœtus. The specimens used in the investigation were carefully chosen as not having been exposed to absorption of copper, and the metal was excluded from all apparatus employed. We may therefore conclude that any quantity above 4 milligr. ($\frac{1}{16}$ gr.) found in these organs is abnormal, and results from direct administration of the drug (Bergeron and l'Hôte, quoted *Lancet*, i., 1875, p. 255). In the case of the two wives of Moreau, 120 milligr. and 80 milligr. were found respectively (*British Medical Journal*, ii., 1874, and i., 1875). In a case where ammonio-sulphate of copper had been taken three months before death, nearly 300 milligr. ($4\frac{1}{2}$ gr.) were obtained from the liver, a good instance of its slow elimination (Bournevette and Yvon: *Revue Scientifique*, 1874, p. 859). Rabuteau found 16 ctgr. ($2\frac{1}{3}$ gr.) in 1,000 grammes liver also three months after the last dose —43 grammes in all of ammonio-sulphate had been taken (*Gazette Hebdomadaire*, March, 1877).

Physiological Action (External).—The sulphate, which is the salt most commonly used, has little action on the sound skin, but when applied to wounds or mucous membranes, it coagulates the albumen, and forms a thin film on the surface. The pure salt, or its concentrated solution, acts as a caustic; weaker solutions act as stimulants and astringents, both forms producing more or less condensation of the neighboring tissues. They exert, also, some antiseptic power, partly by decomposing sulphuretted hydrogen, and partly by destroying low organisms, whether animal or vegetable. Any conclusions drawn from the effects of the smoke and

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vapors of copper foundries are rendered doubtful by the coexistence of sulphurous acid, arsenic, etc. Vegetable life of all kinds is destroyed in the immediate neighborhood of such works.

PHYSIOLOGICAL ACTION (INTERNAL).—*Digestive System.*—In the lower animals, salts of copper seem to be uncertain in their effects, at least when given by the mouth. According to Orfila, vomiting is the earliest and most marked symptom, and Drouard found that 12 gr. of sulphate caused fatal gastric inflammation in dogs. On the other hand, Galippi could not poison dogs with pure copper salts, for small doses were tolerated, and large ones were so nauseous that he could not get enough swallowed or retained (*Bulletin de Thérapeutique*, 1875). Ducom and Burq also report that dogs can take from 15 to 60 gr. daily of soluble salts of copper for a varying time without ill-effect on the general condition, with the exception of vomiting at first; long continuance of this medication at length impaired appetite and digestion, and thus led to death from exhaustion (*Bulletin de Thérapeutique*, 1875).

In man, small doses ($\frac{1}{4}$ gr.) of a soluble salt of copper exert a tonic astringent action, but if continued for a long time impair appetite and digestion, and cause diarrhœa from irritation. The effects of frequently repeated minute doses have lately excited special attention, on account of the adulteration with copper of many preserved vegetables. Thus, in the French preserved *green peas*, 0.31 to 0.56 gr. has been found in each tin, and by some chemists, and even medical men, this quantity has been pronounced injurious (M. Pasteur and others: *British Medical Journal*, 1876–77). Vulpian, however, says that any copper compound contained is insoluble and harmless, and that no evidence exists to the contrary; and Galippi, after the crucial test of eating them freely for some time, found no bad result (*British Medical Journal*, i., 1877). In a 4-lb. loaf of bread .4 to 1.8 gr. has been found, and the latter amount might become serious (*Medical Times*, i., 1871, p. 509). Doses of 1 to 3 gr. induce a sense of constriction in the gullet, and vomiting occurs in a few minutes without much nausea, and is commonly attended with diarrhœa; 5 to 15 gr. act as a powerful irritant emetic.

Lauder Brunton and West have experimented to ascertain whether cupric salts cause vomiting by irritation of the stomach or of the vomitive centre in the medulla. Into the jugular vein of cats they injected a neutral albuminate of copper (which would not cause coagulation of blood), and retching and vomiting followed. Previous section of the vagi did not prevent the retching, but it did prevent evacuation of the stomach, and after section of the vagi and the splanchnic nerves neither retching nor vomiting occurred: hence they conclude that these symptoms depend upon gastro-intestinal irritation, not upon a direct excitement of the central organs (*St. Bartholomew's Hospital Reports*, 1876).

Toxic Action.—Half an ounce given at one time by the mouth pro-

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duces severe symptoms of irritant poisoning, including metallic taste, feeling of constriction, thirst, salivation, nausea, vomiting, purging, and severe cramping pain with tenesmus; the abdomen is distended and tender, the evacuations greenish or containing blood; the face may be flushed and swollen, the gums ulcerated, and sometimes jaundice occurs; death may follow from enteritis or exhaustion within a few hours or days. From 1 to 2 oz. of sulphate or acetate may be reckoned a fatal dose, though recovery has occurred after 5 oz., when vomiting has been free (Toussaint and others); in practice a fatal issue is rare.

Blandet asserts that *enteritis*, though commonly produced by carbonate or acetate of copper, does not occur from the sulphate, and in one case, where 300 gr. were taken, vomiting, suppression of urine, and subsultus occurred, yet recovery took place without enteritis (*Medical Times*, i., 1874); the danger of the drug has doubtless been exaggerated, and Hönerkopf gave in seventy-two cases, 5 grammes, and in eighteen cases, nearly 3 grammes without injury, but in other cases enteritis has been caused by it.

Acute copper-poisoning occurs most often from accidental contamination of food cooked in copper vessels, which, when perfectly clean and pure, are not harmful, but *under* the influence of air and moisture, vinegar, salt, or hot fats, carbonate, acetate, and oxychlorides of copper are formed, and the admixture of these salts ("verdigris") with the food is exceedingly injurious, causing severe colic, vomiting, headache, and pyrexia; tympanitis is sometimes very marked, and numbness and tremor of the limbs have been noted (Taylor, Armstrong: *Medical Times*, 1844). Similar symptoms, with scanty urine and excoriations about the mouth, followed the use of water boiled in a copper kettle, and of injections from a brass syringe (Amyot: *Medical Times*, 1859; Boggs: *Lancet*, 1869). An epidemic, much resembling dysentery, occurred on board an Indian emigrant ship from using copper for the cooking of rice with ghee or butter (Moore: *Lancet*, 1846). If only one portion of the contaminated food has been taken recovery is usually rapid and complete, in proportion to the amount of vomiting; but if more be taken and not rejected, there remains a tendency to colic, vomiting, or diarrhœa, with much debility. Should death follow, there will be found intense redness of the intestinal tract or actual ulceration, according to the stage of the poisoning; perforation is rare (Taylor).

Chronic Copper-Poisoning—"*Cuprismus Chronicus.*"—While by some observers this condition has been described as marked and frequent, by others its existence has been denied, and the symptoms explained by adulteration with lead, etc. The truth lies between extreme views—some amount of copper-poisoning may be traced among workers with the metal, but it is not very serious. Working in pure metallic copper without heat causes no bad symptoms (Hirt, Maisonneuve), but particles

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of oxide and cupric salts in the air of heated rooms may induce dyspnœa and laryngeal spasm. "Gold-printers," working with brass-alloy in fine powder, sometimes get vomiting, gastric pain, and anæmia; the hair becomes green-colored (Taylor). Dr. G. Harley has described a case of sudden colic with nausea, but neither diarrhœa nor constipation, in a copper-plate printer after cleaning plates coated with verdigris: there was a purple line on the gums (*Lancet*, 1863). Blandet was the first to describe a more serious chronic cuprismus as existent in Paris workshops, and marked, besides the green coloration, by colic with remissions, fever, lassitude, nausea, bilious vomiting, and diarrhœa, alternating with constipation (*Gazette Médicale*, 1845). Sir D. Corrigan recorded seven instances in brass-founders and engineers with similar symptoms, also emaciation, cough, and night-sweats; but two of these had organic lung disease, and the cases are not conclusive (*Dublin Hospital Gazette*, 1854). A band of light or reddish-purple on the gum-margin is described as characteristic, but really indicates an *inflammatory* condition which may arise from other causes (Bucquoy: *Union Médicale*, i., 1874). Bailly describes the true copper bluish-green or blue line as on the *teeth* only, not on the gum, which, however, was commonly inflamed: by analysis he detected copper in the blue line. Perron reported the prevalence of dyspepsia, "enteritis," and phthisis, among Swiss watchmakers working with an alloy of gold and copper; they had green coloration of the teeth, but mal-hygiene was a more likely explanation of their impaired health (*Medical Times*, 1861). Dr. Clapton brought before the Clinical Society cases of irritative dyspepsia in a flower-girl and a copper-smith, but his inquiries about copper-workers verified the absence of any special disease among them ("Transactions," vol. iii.). Chevallier, after an exhaustive inquiry, concluded Blandet's statement to be exaggerated, and failed to verify a true "copper colic" (*Annales de Hygiène*, 1859); any severe cases were found complicated by the presence of lead in the material used. Christison and Chomel reached the same conclusion. Hirt, while allowing that verdigris-makers may suffer from intestinal catarrh, and even from some amount of paralysis, blames rather lead, zinc, or arsenic in observed cases of severe "colic." I have known brass-founders get periodic attacks of colic and vomiting followed by rigors—a condition known in the workshops as "brass-founders' ague," and induced when the alloy is melted, and they are much exposed to its vapor—but have connected it rather with zinc or arsenic than copper. Pécholier and Pietra Santa, reporting on the health of verdigris-workers, describe local irritation of mucous membranes, but otherwise good health: they note especially the absence of colic and of chlorosis (*Medical Times*, 1864); and Maisonneuve concluded that though gastro-intestinal disorder may be induced by such work, the symptoms are neither severe nor persistent (Ranking, i., 1865).

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Pathological Changes.—In animals that had taken copper for a long time Mair observed softening and degeneration of the liver, and in one case of poisoning by the sulphate Maschka attributed the jaundice to fatty degeneration. The kidneys were similarly affected (*Sydenham Society's Year Book*, 1873).

Nervo-Muscular System.—If ¼ gr. of oxide of copper be injected under the skin of a rabbit, there will quickly follow unsteadiness in walking, which will gradually pass into complete motor paralysis: the respirations and pulse become feeble, and muscular irritability becomes less, till finally death occurs from paralysis of respiratory muscles (Harnack: *Schmidt's Jahrb.*, 1874). Falck noted very similar effects, with fall of temperature and progressive general paresis, ending in death from cardiac palsy, after hypodermic injection of sulphate, nitrate, and chlorate of copper (*Deutsche Klinik*, 1859); sensation was unimpaired, and the paralysis was limited to striped muscular tissue.

It has been remarked that many *emetic* medicines, *e.g.*, antimony and apomorphia, produce also muscular paralysis, and there may be some direct connection between it and severe vomiting: in Falck's experiments, however (with hypodermic injections), vomiting was not produced. In cases of acute copper-poisoning in men the nerve-symptoms are such as headache, giddiness, prostration, restlessness, tremor, subsultus tendinum, convulsion alternating with stupor or comparative clearness of mind, and sometimes a motor or sensory palsy, partial and temporary in character: such symptoms are mainly secondary to the gastric irritation.

Respiratory and other Systems.—There is not much to be said about the special action of copper on other parts of the body, but in the course of acute poisoning, respiration becomes hurried and labored, the pulse small and usually quickened, and the extremities cold; suppression of urine has been recorded, but among workers in copper, absorbing slight amounts daily, *diuresis* was a usual symptom (Clapton).

Synergists.—Salts of lead and zinc, silver and gold, are allied in action to those of copper. Depressing vital conditions favor the development of its irritant properties.

Antagonists—Incompatibles.—Metallic sulphides, alkalies, and alkaline earths, iodides, and vegetable infusions containing tannin, are chemically incompatible with salts of copper: sugar also reduces them. In cases of poisoning, the action of sugar is too slow to be effective, and magnesia, though it may retard bad effects, does not wholly prevent them, since the hydrated oxide of copper is soluble. Sulphide of iron decomposes copper salts, forming an insoluble cupric sulphide, and may be used, but the best antidote is said to be ferrocyanide of potassium (yellow prussiate of potash), which should be given freely: the resulting copper salt is insoluble (*Medical Times*, ii., 1854). Albumen, which may be given in the form of egg and milk, forms an albuminate of copper, but this is

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not inert and should be removed afterward by the stomach-pump (Schroeder). In phosphorus-poisoning, copper, though praised by Bamberger, is not so good as turpentine (*v.* pp. 43–44).

THERAPEUTICAL ACTION (EXTERNAL).—Applied in lotion, ointment, powder, or crystal, sulphate of copper, "blue-stone," or "blue-vitriol," acts as a stimulating astringent, or a moderately severe caustic. It unites with albuminous secretions to form an insoluble albuminate of copper, which, acting like a new cuticle, protects the injured part from the atmosphere, and promotes the healing process. Equal parts of sulphate of copper, alum, and nitre, fused with four parts of camphor, form a caustic of some celebrity known as "lapis divinus," or green-stone.

Tinea Tarsi—Trachoma.—In these chronic, recurrent disorders of the eye-lashes and lids, the crusts and muco-purulent discharge, and in severe cases the lashes, should be carefully removed, and a crystal of copper sulphate lightly applied to the affected parts. This treatment has the recommendation of Sir W. Wilde (*Dublin Quarterly Journal*, No. 10), of Galezowski, and other authorities, and Mr. Williams (Boston) has published good practical instructions concerning it (Ranking, ii., 1870). I myself commonly prefer this remedy to either zinc or silver, since it is milder, and causes less pain; I generally combine with it the use of a dilute mercurial ointment.

Aphthous Stomatitis.—Sulphate of copper, either applied lightly in substance, or brushed over the affected part in strong solution, removes the white curdy deposit and induces healing of abrasions and ulcerations about the gums: 10 gr. mixed with about 1 oz. of honey is a good form for its use in children. Sir James Paget recommends a gargle containing 1 to 2 gr. of sulphate in 1 oz. of water, as useful in salivation, free purging being secured at the same time (*Medical Times*, i., 1858). A similar lotion will destroy diphtheritic membrane.

Indolent Ulcer—Rectal Ulceration.—The solid crystal of the sulphate is a good stimulant to indolent ulcers, and a good caustic for exuberant granulations. Dissolved and used as an injection it is of service in various forms of ulceration affecting the rectum, especially, according to Mr. C. Heath's experience, in the later syphilitic forms, when the dorsal surface, or sometimes the whole circumference of the bowel within two inches of the anus, is affected, and there is much muco-purulent discharge. For such cases Mr. Heath recommends an injection containing about 10 gr. of sulphate to the pint, a fourth part to be used at one time, and retained for ten minutes: this has an excellent astringent effect, and should be combined with the use of mercurial ointments locally, and iodides internally (*Lancet*, i., 1873).

Cancer.—The arsenite of copper is said to be a valuable application for cancerous sores. Mr. Taylor (Liverpool) used it with an equal part of mucilage, and found it a good escharotic, disinfectant, and at the same

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time sedative dressing (*Lancet*, ii., 1864); it has not, however, been much used.

Skin Diseases.—In parasitic cases, such as ringworm and scabies, the sulphate of copper has been applied with success: in the former Dr. Graves recommended a wash containing 10 gr. in the ounce, a strength which may, with advantage, be doubled: an ointment containing a similar proportion mixed with lard has cured scabies (*Lancet*, i., 1846). In ichthyosis, this ointment has also been recommended by Mr. E. Wilson, and the solid crystal is often used for verruca (wart) and molluscum.

Gonorrhœa—Leucorrhœa—Gleet.—In these disorders an injection containing sulphate of copper, 1 to 2 gr. in the ounce, is often a useful alternative to injections of zinc or lead, or it may be combined especially with the acetate of lead. Dewees and also Diday have shown the value of cupric injections in such cases (*Archives Gén.*, xviii., p. 385), and Dr. P. Foster has more recently illustrated the same (*Medical Times*, ii., 1873). In balanitis a copper lotion is useful.

Bubo, etc.—Good results have been obtained after surgical evacuation of a suppurating bubo, from injecting a weak solution of copper sulphate into the cavity. M. Danielli found this quickly diminish the secretion, which after simple opening is very apt to re-form (*Bulletin de Thérapeutique*, 1868). M. Diday recommended a strength of 3 gr. to the ounce. The solid sulphate is a good application to syphilitic cracks, patches, and ulceration about the mouth and tongue.

Hydrocele.—As an injection for hydrocele, 2 to 8 parts of sulphate in 200 to 250 of water have been used with success. Dr. Pereira (Oporto) states that twenty-one out of twenty-five cases were cûred with this treatment (*Medical Times*, i., 1861).

Caries—Fistulous Tracts.—Strong stimulating and astringent lotions are sometimes of service in these conditions, especially after the carious bone has been removed or the fistula divided. The "liquor Villati" has been much used abroad in such cases without previous operation. It is made with ½ oz. of sulphate of copper and of zinc, and 1 oz. of lead subacetate, dissolved in 7 oz. of vinegar; M. Notta and M. Nélaton have used this with advantage, but it is painful, and should not be injected more than two or three times in a week (*Union Médicale*, 1866).

THERAPEUTICAL ACTION (INTERNAL).—In small doses the salts of copper exert a tonic influence upon the nervous system, and an astringent effect on mucous membranes, while doses of 1 gr. and upward are emetic. The salts in question clearly resemble in action those of zinc, but are somewhat more irritant.

Chorea.—Although preparations of copper are not now much used in this affection, I can refer to some very good results from the sulphate in my own experience, and especially in cases connected with tænia and other intestinal worms. I think it well worthy of use in cases where there

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is even a suspicion of their existence; it will aid their expulsion if present, and in any case act as a good nervine tonic. I have seen permanent good results from ¼ gr. given three times daily, though sometimes this dose needs to be gradually increased.

Hysteria.—In some cases of hysteria, with general debility, shyness, muscular twitching, etc., marked benefit may be derived from the same treatment.

Epilepsy.—It is probable that of the older cases called epilepsy, and reported as cured by copper, a large proportion were hysterical, but Voisin reports from the practice of Herpin (Geneva) several illustrations of its power to cure chronic and obstinate cases of true epilepsy. He generally used the ammonio-sulphate alone, or alternately with zinc, for many months; the cure continued permanent some years afterward (*Bulletin de Thérapeutique*, i., 1870). Halford made great use of copper combined with quinine in this malady (*Medical Times*, i., 1858), but general experience is not in its favor. Charcot has published a case carefully treated for three months with full doses of the ammonio-sulphate, but the convulsive attacks were rather increased during its use (*British Medical Journal*, i., 1875). I have given the sulphate and the acetate in varying doses and for long periods in many cases, but have not seen benefit from them in true epilepsy, although for epileptiform attacks dependent upon intestinal worms, they have several times proved useful.

Spasmodic Asthma.—In cases where there occur well-marked paroxysms, terminating in the ejection of quantities of mucus, small doses of sulphate of copper repeated frequently until vomiting occurs will usually give relief; but independently of vomiting, in asthma of more purely nervous type, I have observed benefit from ⅛ gr. and upward, given every one to three hours during the attacks, and continued night and morning in the intervals, so as to secure a tonic effect on the nervous system.

Whooping-Cough, in the early spasmodic stage, is often relieved by the same remedy, especially if moderate emesis be produced.

Emphysema—Chronic Bronchitis.—I have seen relief given to the dyspnœa dependent on these conditions by small doses of sulphate of copper continued for some time. I believe it acts partly through the nervous system, and partly like other astringents, by lessening the amount of secretion in the bronchi, and so permitting free access of air.

Tapeworm.—I have often known tæniæ dislodged and passed under the use of small doses of the sulphate; about ⅛ gr. in solution is a suitable amount to commence with, and may be given every morning, fasting. If this dose be steadily and gradually increased, upward of 3 to 5 gr. may be administered without causing vomiting or purging; but should these symptoms occur, the medicine is better omitted for the time, to be resumed in smaller doses if required again. This treatment should be con-

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tinued for eight to ten days or longer, an occasional dose of castor-oil being given when necessary.

Chronic Diarrhœa and Dysentery.—Sulphate of copper is an excellent remedy in these disorders, given in doses of ½ to 1 gr., three or four times daily. Elliotson highly recommended it in somewhat larger doses, and generally combined with opium in a pill ("Medico-Chirurgical Transactions," vol. xiii.), but if opium be really required for pain, I find it better given separately, especially in the form of Dover's powder, at bedtime. Morehead also recommends this treatment ("Diseases of India," i.). In *infantile* diarrhœa, objection has been taken to the use of copper, but I have seen it act most beneficially in obstinate cases, not only when chronic, but also when acute in character, and especially when connected with dentition—the dose may vary from $\frac{1}{10}$ to ¼ gr. several times daily. Pereira specially recommends the remedy in $\frac{1}{12}$-gr. dose. Eisenmann has also recorded its value in the diarrhœa of dentition, and of weaning, and states that he has seen many cases treated by it and cured, when others, not so treated, have become chronic and ended in marasmus (*Bulletin*, June 30, 1859).

In the *diarrhœa of phthisis*, dependent, as it commonly is, on ulceration of the intestine, we often require to use different forms of astringents, and the sulphate of copper is a valuable alternative. Small doses only should be used, in order to avoid nausea and irritation—¼ gr. with the same quantity of opium is advised by Sir T. Watson ("Lectures," ii., p. 216).

In *Enteric Fever* with severe diarrhœa, a similar combination is highly praised by Dr. John Harley ("Reynolds' System," i., p. 419), who "considers it more efficacious than any other medicine." The dose may be increased up to 1 gr., but must be kept small enough to avoid vomiting; quite small doses rather allay gastric irritability.

Cholera.—In this malady, the sulphate has been considered by some physicians so valuable as to be almost a specific. I cannot place great reliance upon it, though I have sometimes observed it relieve the cramps, the retching and purging, and strengthen the weak intermittent pulse, and assist in warding off collapse. The careful observations of Gutmann have rendered improbable any specific action of the drug.

Some *prophylactic* power against cholera has been claimed for copper, for the neighborhood of towns where large copper-works are situated, such as Swansea, Birmingham, Rio Tinto, has been markedly free from the disease, but other circumstances, and other components of the vapor, such as sulphurous acid, must be taken into consideration (*Medical Times*, ii., 1854, ii., 1871). A similar immunity is recorded at the large powder factory at Madras, where the mixed chemicals are said to be exposed to a temperature of 500° F., which would be sufficient to develop sulphurous acid from the sulphur (Mr. Parker: *Lancet*, ii., 1873). More important is

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the fact, that among more than 5,000 copper-workers in Paris, not one was attacked by cholera, during an epidemic which affected other workmen in the proportion of about 1 in every 140; and of the former, not one died of cholera in the course of five epidemics (Burq: *Lancet*, ii., 1873). Dr. Clapton also remarked that the copper-workers seemed to have almost complete immunity from cholera and from choleraic diarrhœa, when it was very prevalent among the neighbors, and the same observation has been made by others. Still, such prophylactic virtue of copper is not usually recognized, perhaps because it is difficult to understand, but Dr. Clapton suggests as some explanation, the disinfectant power of the metal, and its destructive action upon fungi; the subject deserves further investigation.

Croup (*Laryngo-Tracheal Diphtheria*).—In this malady the sulphate of copper has been highly esteemed, especially by German and French physicians, since its first introduction by Hoffmann; he used it mainly as an emetic, but the question has arisen whether it does not exert a *specific* action upon the false membrane. Kissel, who reports successful cases from the use of non-emetic doses of the acetate, supports this view (*Journal für Pharmaco-dynamik.*), and Missoux, who also speaks highly of the remedy, but who gave 5-gr. doses, argues in favor of specific action, because the false membrane, after becoming detached, either does not form again, or if it does so is no longer so plastic, tough, and adherent (*Bulletin de Thérapeutique*, December, 1858, abstract in *Medico-Chirurgical Review*, ii., 1859). In judging of the curative results, we must bear in mind the distinction between simple catarrhal laryngitis and the membranous form (true croup), since the former is more likely than the latter to have a favorable issue independently of treatment, but allowing for this, there can be no doubt that most of the cases of Godfrey and of Beringuier were of the more serious malady; these observers used emetic doses (2 to 4 gr.) and also depletion. Trousseau used it mainly as an emetic, in doses of 5 gr., twice repeated (*Gazette des Hôpitaux*, No. 39). I do not ignore the six fatal cases recorded by Dr. Hannay (*London Medical Gazette*, July, 1840), nor the adverse opinion of Nothnagel, who fears its injurious effects on the intestinal tract, but still I consider the remedy of value. Dr. Crighton states (*Edinburgh Medical Journal*, May, 1868) that out of fifty cases of croup treated by him with the sulphate, only six died; he gave ½ gr. every ten to fifteen minutes till vomiting or marked relief occurred; but even these doses are rather large for children, and, in fact, he records that two of them had violent diarrhœa. I recommend doses of ⅛ to ¼ gr. for children, to be given every quarter to half hour until vomiting is induced; then the dose should be diminished and given at longer intervals so as to avoid too severe effects, and later it may be increased again should it become necessary to produce emesis. This plan may be adopted in true croup during the stage of development

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of the membrane when there is a dry barking cough, and sense of constriction across the chest, with much difficulty of respiration: and it is also serviceable in cases where a loose catarrhal cough assumes a dry croupy character, when there is partial aphonia, and often some sanguineous discharge from the throat and nostril.

The following notes of an illustrative case have been furnished to me by Dr. Mackey:—E. S., a girl, aged three, was hoarse on April 7th; on the 9th became feverish and restless, with hurried, loud, and stridulous respiration, and clutching at the throat; there was no exudation on tonsils: has had castor-oil, poultices, and steaming, now ordered 6 min. of ipecacuanha and 6 of antimonial wine every hour: vomited after the third dose, but the oppression continuing, a teaspoonful of the ipecacuanha wine was given and caused freer vomiting.

On the 10th there was, however, no relief, the stridulous croupy breathing being more marked, the face flushed, not very dusky; pulse 120, respiration 36; drowsy, yet restless. (10 A.M.): to omit other treatment and take ½ gr. of copper sulphate every half-hour in water. (1.30 P.M.): has had four doses; vomited freely after the first two, and slept comfortably; is better, pulse 110, respiration 32. (6 P.M.): one dose since; vomited and moderately purged; pulse 110, respiration 28, temperature 100°; speaks better, and smiles. (11th, 9 A.M.): has slept fairly well, lying down; had two doses, and vomited after each; looks much better; respiration 32, temperature 98°; bowels moved once. 12th: Convalescent, though still some stridor when asleep; an occasional dose of the copper relieves sensibly. The child got quite well.

Diphtheria.—In the ordinary form of diphtheria the sulphate of copper has also been found useful by some observers. Dr. W. Squire speaks of it as one of the most effectual emetics, and recommends a solution of 5 gr. to the ounce to be given in divided doses—a teaspoonful only to young children, so as to induce moderate vomiting ("Reynolds' System," i., p. 147, second edition). In cases of formation of diphtheritic membrane on the cutaneous, or nasal, or vulvar surface, lotions of the sulphate are found to destroy it, and to prevent its re-formation.

Intermittent Fever.—In obstinate quartans, more particularly, the salt has been commended by Hoffmann, Chapman, and others, in ¼-gr. doses, combined with opium, but it has not come into general use.

Phosphorus-Poisoning.—Bamberger, Eulenburg, and others have recommended the sulphate as an antidote in this form of poisoning, which is not uncommon in Germany; the salt certainly is reduced by phosphorus, and it is supposed that the latter may be coated with the metal, and thus rendered inert (*v.* vol. i., p. 43): an emetic effect also is serviceable, as it is also in narcotic and other cases of poisoning (Nothnagel, p. 333).

Syphilis.—Aimé Martin and Oberlin have recently published the re-

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sults of fifty cases of secondary and tertiary syphilitic affections treated with sulphate of copper; in many of these it is said to have acted more promptly than mercury; only in one patient vomiting took place on the first day, but very soon the metal was borne well; a green margin of the gums without an inflamed state of the mucous membrane was observed in a few cases, but disappeared soon; the remedy was given in solution, and 4 to 8 or 12 milligr. were used daily. To a full bath 20 grammes were added (*Gazette Médicale de Paris*, November 15, 1880). Zeissl has tried copper in syphilis, but his results were only partly satisfactory (*Wien. Med. Presse*, November 29, 1880).

PREPARATIONS AND DOSE.—*Cupri sulphas:* as a tonic and astringent, ¼ gr. to 1 or 2 gr.; as emetic, 5 to 8 gr. (for adults)—best administered in divided doses at short intervals; a child may have ⅛ to ¼ gr., according to age and strength, repeated every five to fifteen minutes till vomiting occur; it should then be omitted for a time, or purging may succeed. The *oxide* of copper has been used in doses of ¼ to 1 or 2 gr., and the *double chloride* with ammonium in ¼ or ½-gr. doses, every two or three hours. A *tinctura cupri acetici* has obtained some favor on the Continent under the auspices of Rademacher. It is prepared by mixing 24 parts of copper with 30 parts of acetate of lead in 136 parts of distilled water: boiling this in copper vessels, then adding 104 parts of spirit, and macerating for four weeks in a closed glass vessel, then filtering. It forms a green liquid of metallic taste, and is the chief remedy for all "copper diseases," and "especially for hyperæmiæ, stases, and exudations."—5 to 15 drops and upward are given thrice daily (Kissel, Husemann). *As a lotion*, 1 to 2 gr. of sulphate in the ounce, *as a parasiticide*, 10 to 20 gr. to the ounce may be used, and a stimulating astringent *ointment* may be made with ung. sambuci in the same proportion.

[PREPARATIONS, U. S. P.—*Cuprum ammoniatum*, *Cupri subacetas*, and *Cupri sulphas.*]

FERRUM—IRON, Fe,=56.

Iron, the most abundant and the most useful of metals, occurs extensively in the mineral kingdom, its principal ores being either oxides, as the magnetic iron ore, or carbonates, as clay iron-stone. It occurs also in many mineral, so-called *chalybeate* waters, generally as carbonate with excess of carbonic acid, sometimes as ferrous chloride or sulphate. In the animal kingdom it is an essential constituent of blood, being contained, though only in minute quantity, in the hæmoglobin of the red corpuscles. It occurs largely also in the vegetable kingdom, and may be traced in the

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ashes of almost all plants. Sometimes the pure metal is found native, and is then commonly supposed to be of meteoric origin.

CHARACTERS AND TESTS.—Iron is hard, malleable, ductile, and of great tenacity; sp. gr. 7.7. Exposed to moist air, it becomes covered with a reddish layer—rust—which is mainly hydrated sesquioxide. It forms two distinct classes of compounds known as proto- or ferrous salts, and per- or ferric salts; in the former, it combines with not more than two atoms of a monad, as Cl or I; in the latter, it requires three, or, as most consider, six atoms of a monad for saturation ("Smith's Commentary"). *The ferrous or proto-salts* are commonly lighter in color, less astringent, and less soluble in alcohol; they have a marked tendency to absorb oxygen, and to become ferric compounds, hence most of the officinal ferrous salts are in a partially oxidized state, but to some, sugar is added to prevent such change as in syrupus ferri iodidi, and ferri carbonas saccharata. *Ferric or per-salts* are generally brownish-yellow, astringent, and soluble in alcohol, and are not prone to change: within the body, however, they are probably reduced to proto-salts.

The general tests for iron are—(1) the color test, with tannic or gallic acid; (2) the precipitate and blue color produced by ferro-cyanide; and (3) by ferrid-cyanide of potash. (1) Tannins change the per-salts of iron bluish-black, and act similarly, though more slowly, with proto-salts. (2) The yellow prussiate of potash (ferro-cyanide) gives a deep blue precipitate with per-salts of iron, and a whitish or light blue one with proto-salts. (3) The red prussiate (ferrid-cyanide) gives no precipitate with the per-salts, but the liquid becomes of a dark color: a deep blue precipitate with proto-salts (Turnbull's blue).

Sulphuretted hydrogen and ammonium sulphide are also used as tests for iron salts; thus, in acid solutions of pure *ferrous* salts, the former gives no precipitate, while with *ferric* salts it throws down a nearly white precipitate of sulphur, with reduction to the ferrous state: $Fe_2Cl_6+H_2S=2FeCl_2+2HCl+S$. The same tests will also precipitate any copper contained in acid solutions of iron salts.

By acids iron is readily dissolved, with formation of metallic salts and evolution of hydrogen.

COMPOUNDS OF IRON.

The large number of officinal iron compounds may be with advantage considered in the following order:—The preparations of the metal itself and its oxides; the astringent preparations; and those which are not at all, or not markedly, astringent.

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FERRUM REDACTUM—REDUCED IRON[1]*—QUEVENNE'S IRON.*

Metallic iron is introduced in the form of soft or wrought iron wire, or nails free from rust, and also combined with some oxide, as ferrum redactum.

PREPARATION.—By passing a stream of hydrogen at red heat over the hydrated peroxide—$Fe_2O_3H_2O+H_4=4H_2O+Fe_2$. At the same time, by incomplete reduction, some magnetic oxide is formed—$3Fe_2O_3+H_2=2Fe_3O_4+H_2O$.

CHARACTERS.—Pure reduced iron is an impalpable grayish-black powder, strongly magnetic, and showing metallic streaks on firm pressure. The oxide can be separated from the metal, and its amount ascertained by digestion with iodine and iodide of potassium, which dissolves the metal alone; of this, it should contain at least 50 per cent.; a little sulphide is sometimes present, and is liable to cause disagreeable eructation.

FERRI OXIDUM MAGNETICUM—MAGNETIC OXIDE OF IRON, $Fe_3O_4=232$.

Black oxide—containing about 20 per cent. of water.

PREPARATION.—This being a mixture of proto- and peroxide, is prepared by adding a mixed solution of proto- and persulphate of iron to an excess of soda; the precipitate is washed and dried at a moderate temperature (120°), for at a greater heat it would absorb oxygen.

CHARACTERS AND TESTS. — A brownish-black powder, tasteless, strongly magnetic, and soluble in acids without effervescence: bubbles of hydrogen would show the presence of metallic iron.

FERRI PEROXIDUM HUMIDUM—MOIST PEROXIDE OF IRON, $Fe_2 6HO_2=214$.

PREPARATION.—By pouring solution of persulphate of iron into excess of soda, and washing away the sodium sulphate: a similar precipitate would be thrown down by potash or ammonia.

CHARACTERS.—A pasty mass, reddish-brown in color, and containing water, both combined and uncombined, to the amount of nearly 90 per cent.: it is the only iron preparation used in the moist state: it dissolves readily in cold dilute hydrochloric acid.

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[1] "Reduced" iron means the metal minutely divided by chemical process as distinguished from simple filings or powder (mechanical division); the percentage of metal in this form is often small (Pharmaceutical Journal, August, 1875).

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FERRI PEROXIDUM HYDRATUM—HYDRATED PEROXIDE OF IRON, $Fe_2O_3H_2O$, =178.

PREPARATION.—By drying the moist peroxide last described at a temperature of 212°, and reducing to powder.

CHARACTERS.—A tasteless powder, distinguished from the magnetic oxide by its dark-brown color, and its being non-magnetic.

(The astringent preparations of iron are mainly those which are formed by direct solution of the metal in the strong mineral acids, and include the chloride, nitrate, and sulphate.)

LIQUOR FERRI PERCHLORIDI FORTIOR—STRONGER SOLUTION OF PERCHLORIDE OF IRON, (Fe_2Cl_6,)=325.

PREPARATION.—By dissolving iron wire in an excess of hydrochloric acid (by which a ferrous chloride is obtained), and treating this with nitric acid to peroxidation—thus

$$Fe+2HCl=FeCl_2+H_2.$$

$$6FeCl_2+2HNO_3+6HCl=3Fe_2Cl_6+2NO+4H_2O.$$

Sufficient distilled water is added to give a sp. gr. of 1.44. The per-salt could not be formed by the first-mentioned acid alone, because the nascent hydrogen which is set free, reduces ferric salts to the ferrous state.

CHARACTERS.—The liquid is at first black from the combination of some nitric oxide (NO) with ferrous salt, but on heating the mixture the gas is expelled, and an orange-brown solution remains: it generally contains some free acid, and has a very strong styptic taste.

Liquor et Tinctura Ferri Perchloridi (*v.* p. 180).

LIQUOR FERRI PERNITRATIS—SOLUTION OF PERNITRATE OF IRON, Fe_26NO_3, =484.

PREPARATION, etc.—By dissolving iron wire in nitric acid, and diluting to the proper strength, and a sp. gr. of 1.107. It is a clear solution of reddish-brown color, acid and astringent.

LIQUOR FERRI PERSULPHATIS—SOLUTION OF PERSULPHATE OF IRON, Fe_23SO_4,—400.

PREPARATION, etc.—By boiling a solution of the proto-sulphate with some additional sulphuric and some nitric acid. A dense solution of reddish-brown color; very astringent.

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FERRI SULPHAS—SULPHATE OF IRON, $FeSO_4 7H_2O$.

The *proto-sulphate of iron* is the salt from which the greater number of the other compounds are prepared. Three forms of it are officinal—ferri sulphas (green vitriol); ferri sulphas exsiccata, and ferri sulphas granulata.

PREPARATION.—By dissolving iron wire in dilute sulphuric acid, and crystallizing.

CHARACTERS.—The *sulphate* occurs in oblique rhombic prisms, of greenish-blue color and very styptic taste, soluble in water, insoluble in spirit. Exposed to air, it absorbs oxygen and turns brown from formation of ferric sulphate: if the crystals be rich green in color, some ferric oxide is present, but if nearly free from any ferric salt, the precipitate with yellow prussiate of potash will be nearly white. The crystals effloresce slightly in dry air; at 238° F. they lose most of their water of crystallization, and at 400° only one atom of water is retained, and the salt becomes a yellowish-gray powder.

Ferri Sulphas Exsiccata—Dried Sulphate of Iron ($FeSO_4H_2O$). This does not alter on exposure, and is not gritty: 3 gr. are equal to 5 gr. of the crystallized salt.

FERRI SULPHAS GRANULATA—GRANULATED SULPHATE OF IRON.

PREPARATION.—By filtering a boiling solution of ordinary sulphate into cold rectified spirit, constantly stirring.

CHARACTERS.—Occurs in small green granules which are stable, and if carefully dried retain their properties many years.

TINCTURA FERRI ACETATIS—TINCTURE OF ACETATE OF IRON.

PREPARATION.—By adding an alcoholic solution of acetate of potash to one of persulphate of iron, agitating for an hour, and filtering from the precipitate of sulphate of potash, which is insoluble in spirit.

CHARACTERS.—A deep-red liquid which is apt to decompose and become muddy; its taste is not unpleasant, and its degree of astringency moderate.

FERRI CARBONAS SACCHARATA—SACCHARATED CARBONATE OF IRON, $FeCO_3$, =116.

PREPARATION.—By adding carbonate of ammonium to ferrous sulphate, each salt being dissolved in boiling water, so as to avoid the presence of air; the precipitate is collected, washed, and rubbed with sugar.

CHARACTERS.—The precipitate is at first white, then green and finally

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becomes red from absorption of oxygen and formation of ferric oxide. There is no *ferric* carbonate, but what is often sold as carbonate is a brown ferric oxyhydrate containing only a trace of the desired salt, which is very unstable and prone to oxidation; to preserve it from this as far as possible, it is rubbed up with sugar.

FERRI IODIDUM—IODIDE OF IRON, FeI_2, =310.

PREPARATION.—By heating together iron wire with twice its weight of iodine, and eight times its weight of water, until the solution becomes colorless; it is then filtered and evaporated to solidity.

CHARACTERS.—A crystalline, green substance with a tinge of brown, containing about 18 per cent. water of crystallization and a little oxide of iron, without odor, deliquescent, soluble in equal parts of water, forming a greenish solution which very readily absorbs oxygen, and changes into free iodine and ferric peroxide. It is decomposed also by heat, emitting colored vapors of iodine; the altered solution may, however, be restored by warming with more iodine and iron, and may be preserved in strength by keeping a piece of iron in it; so that as iodine is liberated, it can recombine to iodide. Syrup will preserve to a great extent, and it is in the form of syrup that it is most frequently ordered (*v.* p. 179); it is incompatible with alkalies and their carbonates.

A Bromide of Iron is prepared similarly by direct combination, and is sometimes prescribed, but is not yet officinal.

FERRI ARSENIAS—ARSENIATE OF IRON, $Fe_2As_2O_8$, =446.

PREPARATION.—From a solution of sulphate by the addition of a mixed solution of arseniate, and of acetate of soda: the precipitate is filtered and dried at a low temperature to avoid oxidation. In this process, arseniate of iron, sulphate of soda, and free acetic acid are formed; without the acetate of soda, free sulphuric acid would be present, and this would dissolve the iron salt: the decomposition is complex.

CHARACTERS.—Arseniate of iron is an amorphous powder, white when first formed, but becoming gray or greenish-blue from absorption of oxygen: insoluble in water; soluble in hydrochloric acid. Thrown on live coals it evolves the garlic odor of arsenic, and is essentially an arsenical remedy, for the quantity of iron in any admissible dose is insignificant.

FERRI PHOSPHAS—PHOSPHATE OF IRON, $Fe_2P_2O_8$, =358.

PREPARATION.—By a process analogous to that for the arseniate; sulphate of iron is precipitated by phosphate of soda, some acetate of soda being also added to neutralize any free sulphuric acid that would be

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liberated from the iron salt. The precipitate is dried at low temperature to prevent oxidation.

CHARACTERS.—A slate-blue amorphous powder, almost tasteless, insoluble in water, soluble in acids.

Syrupus Ferri Phosphatis (*v.* p. 180).

Another group of iron compounds may be made of the *scaly* preparations, which are compounds of the metal and often of some other drug in addition, with a vegetable acid, such as tartaric or citric acid.

FERRUM TARTARATUM—TARTARATED IRON.

PREPARATION.—Freshly precipitated peroxide of iron is dissolved in solution of acid tartarate of potash and allowed to stand for twenty-four hours, concentrated at a moderate temperature, and poured, when of syrupy consistence, on flat plates to solidify.

CHARACTERS.—Occurs in dark garnet-colored scales; soluble in water, sparingly so in spirit. If boiled with potash or soda it deposits peroxide of iron, but is distinguished from the ammonio-citrate by not evolving ammonia under the same conditions, and also by leaving an alkaline ash.

FERRI ET AMMONIÆ CITRAS—CITRATE OF IRON AND AMMONIA.

PREPARATION.—By dissolving freshly precipitated peroxide of iron in citric acid with heat, adding ammonia to neutralization, evaporating to consistence of syrup, and then drying in thin layers on plates.

CHARACTERS.—Occurs in transparent ruby-red scales, of sweet astringent taste and slightly acid reaction, soluble in water, almost insoluble in spirit. If boiled with soda or potash, it evolves ammonia, but alkaline carbonates do not readily decompose it, and it may, therefore, be given with them in effervescence with citric acid: the iron salt should be put into the acid solution.

FERRI ET QUINIÆ CITRAS—CITRATE OF IRON AND QUININE.

PREPARATION.—By dissolving freshly precipitated peroxide of iron and quinine in solution of citric acid, adding ammonia and evaporating to dryness at moderate temperature. The product is a triple citrate of iron, quinine, and ammonium, and contains both a ferrous and a ferric compound.

CHARACTERS AND TESTS.—Occurs in greenish-yellow scales which become darker by age; they are at first deliquescent and very soluble in cold water, but become less so on exposure to light; it has a chalybeate, and at the same time a bitter taste. It should contain 20 per cent. of Fe_2O_3, and 16 per cent. of quinia, but the proportion of the latter varies,

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falling sometimes to 4 per cent. The solution is slightly acid: soda precipitates the reddish-brown peroxide Fe_2O_3, and ammonia a white deposit of quinia.

The citrate of quinine with iron and zinc, and with iron and strychnia, and many other double compounds, have also been prepared in granular effervescent form.

ABSORPTION AND ELIMINATION.—If, in former times, the absorption of *any* medicine was commonly denied, with us the absorption of *all* is now commonly accepted as a necessary condition of their acting on the system, and yet the absorption of medicinal doses of iron has been doubted by some eminent men, and mainly because chemists, after giving the drug to animals, have often failed to detect an increased quantity of it in the vena portæ, and have sometimes failed to find any in the urine.

On appeal to the clinical evidence of improved color and tone after the use of iron, the objectors attribute such results to a local tonic action upon the gastric mucous membrane leading to improved digestion; but besides that iron salts have often rather a contrary effect, it would not, in any case, account for all that we see, nor for the chemical changes produced in the blood. It seems more reasonable to allow that the medicine, which we can prove to be, to some extent, soluble in the gastric fluids, should be really absorbed, at least to the extent of its solubility. From most articles of diet certainly traces of iron are absorbed, as we know from detecting the metal in the blood and tissues: if there be some failure in the supply, or in its assimilation, then color and strength fail (just as when iron is removed from a *soil, white* vegetables and *chlorotic* oats spring up from it), and conversely health and color usually return when suitable ferric preparations are added to the nutriment or to the soil. Definite facts in proof of absorption are such as the following: Tiedemann and Gmelin administered to a horse about 6 dr. of sulphate of iron, and found an increased amount of the metal in blood from the splenic and hepatic veins, and in some experiments, in the lymph also. Manghini recorded a distinct increase in the amount of iron in the blood of dogs when he added the metal to their food (Bayle: "Biblio. de Thérap.," v., iv.). Wöhler, though he failed to detect iron in the urine after giving various preparations of it to animals, yet succeeded in detecting it by means of tincture of galls in the urine of patients taking chalybeate waters; he also noted its occasional presence in calculi and in urinary sediments (Treviranus: *Zeitschrift*, vol. i., 1824, p. 302). Quevenne, in his careful and admirable memoir, says that only a minute quantity can be detected in normal urine, but that after medicinal doses the amount is increased slightly: in the bile and fæces the increase is greater (Bouchardat: *Archives de Physiol.*, etc., No. 2, October, 1854). Schroff found that when small doses were given to animals, elimination by the kidneys was evident, and began sooner, and continued longer, than after larger

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doses; he recorded also the curious fact (and Becquerel corroborated him), that even during the use of equal and continued doses, the amount passed in the urine was subject to much fluctuation, implying that that secretion was not the best gauge of absorption. Bence Jones speaks of detecting iron in the urine within ten minutes of the administration of a soluble salt, also of the rapid diffusion of another portion of it into the textures and corpuscles (Lectures, *Medical Times*, ii., 1860, p. 245), and Délioux de Savignac affirms that it may be readily and frequently found in all the secretions (*Gazette Méd. de Paris*, April 25, 1874). Bistrow verified the presence of nearly double the ordinary amount of iron in the milk of a goat after the administration of 15 to 40 gr. of lactate of iron; elimination of increased amount began in the milk forty-eight hours after giving the dose, implying a slow absorption or long detention in the tissues (Husemann). In Dr. Marcet's classical case of a man who had swallowed several knives, particles found in the bile were attracted by the magnet, and that liquid contained more than double the normal amount of iron ("Philos. Trans.," xii.).

More modern observations are those of Rabuteau, who passed through a tube varying amounts of protochloride of iron into the stomach of dogs, which were killed a few hours afterward; the stomach was found to contain only a small amount of the compound, the intestine somewhat more, but the greater part had passed into the blood, which was found on analysis to contain, in these cases, distinctly more iron than under ordinary conditions (*Journal de Thérapeutique*, 1875). In another series of experiments he injected the same salt directly into a vein; it did not cause coagulation—on the contrary, it increased the fluidity of the blood, and yet no increased amount of iron was found in the urine. The greater part of what was injected passed away by the intestine, proving again that failure to find the metal in the urine is no proof of its non-absorption into the blood; similarly, the protoxide was injected in large doses by Papi, and was found unchanged in bile and fæces, but not at all in urine (Husemann).

I cannot doubt that a true absorption of iron compounds occurs from the gastro-intestinal mucous membrane, though it may be often partial and incomplete, and is certainly rather slow and limited: it varies according to the preparation used, the reaction of gastric juices, and the state of the stomach as to food, etc. Woronichin showed that while chloride of sodium promoted the assimilation of iron, chloride of potassium much increased its elimination (*Wiener Med. Woch.*, ii., 1868), and Brucke demonstrated in rabbits, that after a certain period the system, or more accurately the corpuscles, became so charged with the substance that it was no longer retained in the tissues, but passed almost wholly in the urine (Husemann).

With reference to the absorption of iron from the cellular tissue, C.

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Bernard performed a well-known experiment, injecting ferro-cyanide of potassium into the thigh of an animal, and solution of lactate of iron into its neck; the spot in the thigh remained unchanged in color, but the neck quickly showed blue, implying that the cyanide had been taken into the circulation, and so reached the iron, but the lactate of iron had not travelled to the cyanide. Soluble salts, however, are certainly absorbed from wounds, and from the bared skin (Husemann), and recently, good effects have been obtained from hypodermic injection of a double salt (pyrophosphate and citrate) "in pernicious anæmia," after failure of ordinary means (Huguenin: *Schmidt's Jahrb.*, Bd. clxxiii., 1877). The observations of Hamburger as to the absorptive powers of the vagina (tampons soaked in iron solution being introduced into it) were vitiated by his confining analyses to the urine—elimination by that secretion being, as we have seen, very uncertain—and he could come to no definite conclusion (*Prager Vierteljahrschrift*, 1876, p. 145).

If doubts have been expressed as to the fact of iron absorption, there has been still more controversy as to the mode in which it is effected, and this, indeed, may differ according to the preparation employed. The finely divided *metal*, "reduced iron," is first oxidized by the help of water (for if the compound contain any sulphur, disengaged hydrogen makes itself evident as a sulphuret in eructations). The *protoxide* and the *carbonate*, themselves not soluble enough for absorption, are rendered so by the hydrochloric acid of the gastric juice (as evidenced by experiments with the gastric juice of dogs); the *protochloride* does not coagulate albumen, and is readily absorbed. The *sesquioxide* becomes first perchloride and then protochloride, and is absorbed as such (Rabuteau).

It was formerly held that all proto-salts became quickly changed in the system into per-salts, because this change so readily occurs outside the body, but various conditions will prevent or even invert it. Thus, Quevenne notes that a natural protocarbonate remains as such in many mineral waters—that per-salts are reduced by alkaline tartrates, by charcoal, or simply by cold—and that the ethereal "tincture of steel" is rendered colorless and reduced to protochloride by mere exposure to the air and light. Stenhouse found the per-salts to be reduced by organic substances generally, and C. Bernard, after injecting a per-salt into the jugular vein, recovered only a proto-salt from the urine. In short, it is probable that if iron exists at all in the system as a per-salt it is only for a time, and under the temporary influence of an increased amount of oxygen; its rapid change from one condition of oxidation to another is possibly in accord with a general law of the organism (Quevenne).

Salts of the *organic acids*, the citrates, lactates, and tartrates, may be absorbed directly into the blood, the acid becoming quickly oxidized or

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"burnt off," and the metallic base left free to combine with the blood constituents. Rabuteau suggests that a carbonate of iron may be formed, as are carbonates of the alkalies after administration of alkaline citrates, etc.

The *potassio-tartrate* or tartarized iron has seemed to be more readily assimilated than any other preparation (Léras, Mialhe). The *iodide of iron* exhibits the properties of iodine rather than of the metal, and has proved more irritating than simple iron compounds. The whole of the iodine has been found eliminated in the urine after a few days, while but little of the iron has passed out (Quevenne, Melsens), proving that complete separation of the constituents occurs in the system.

Salts of the *mineral acids*—the chloride, nitrate, and sulphate—if given so diluted as not seriously to constringe the gastric membrane, nor to coagulate albumen, may be absorbed *directly* into the blood, and much more quickly than the metallic preparations. (Mialhe suggests that the blood-alkalies combine with, or neutralize, the acids so as to leave the metal free for oxidation or combination.) Stronger solutions must, for their first effect, coagulate the albuminous material they meet with in the stomach. Mitscherlich found a "proto-albuminate" of iron in the stomach of rabbits; but, within certain limits, this compound is soluble both in excess of the iron solution, and in fresh quantities of albumen. Gubler, indeed, recommends it as a good form for administration, being both active and non-irritant. It has been generally held that this compound of iron was absorbed and circulated as a per-albuminate, but, according to Dietl, *proto-albuminates* are much more soluble than the per-salts (*Schmidt's Jahrb.*, 1874); the same has been said of proto-chlorides, but practically both forms are available. The precipitates formed by *per-salts with albumen* are soluble under various conditions; using 1½ part of ferric chloride to an albuminous solution, H. Rose found the precipitate dissolve in an excess of the salt, and when quite fresh, even the "blood-alkalies" dissolved it. When albumen came into contact with weak iron preparations a few drops of weak acid, or sometimes of alkali, were enough to help solution in the gastric juice (Dietl). As qualifying the observation of Lersch that albumen could supply the place of acids as a solvent for iron in the gastric juice, Dietl found that iron albuminate was soluble in soda solutions, that iron phospho-albuminate was soluble in contact with phosphate of soda, and that alkaline phosphates generally favored the absorption of iron salts after they had become albuminates (Schmidt, loc. cit.).

It is probable that iron is not only absorbed as an albuminate, but eliminated mainly by membranes having albuminous secretions, such as mucous and serous membranes. Dr. Ringer refers to experiments in which, after being injected into the blood, most of the iron was detected on the mucous lining of the intestine, the bronchi, the gall and urinary

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bladder, and the serous membrane of pericardium, etc. Gubler relies on such facts to explain the astringent action of iron on various parts distant from the stomach, reasoning that the metal becomes separated by such secreting surfaces from the albumen with which it has been combined, and then recovers and exerts its natural astringency (cf. vol. i., p. 228).

To resume: of the three groups of preparations—the first comprising the reduced metal and carbonate; the second, astringent acid soluble compounds; and the third, soluble non-astringent ones—*all* are susceptible of absorption under favorable conditions, the first comparatively slowly, the second (when diluted) quickly, and the third group to a medium extent. This fact becomes of importance in guiding our choice of a preparation in different maladies. Of either group a certain proportion, according to the dose, the condition of the stomach, etc., may remain unacted upon, and consequently unabsorbed, and pass into the intestine mechanically mingled with the food; at this stage some further proportion is absorbed under the influence of fats (Mialhe), or of alkaline secretions, or of bile. It has long been recognized that the bile contains a relatively large proportion of iron, and Lusanna argued that the greater part, if not all, of the administered metal passed only into the portal circulation from the mesenteric vein, and was eliminated by the bile. More recently the fact has been used as an argument to show that the effete blood-corpuscles are broken up in the liver, and furnish to the bile its large proportion; thus, Dr. Young, after many analyses, fixing .0065 as the amount of iron contained in the 100 grammes of human bile, calculated it to represent 6.63 grammes of corpuscles (*Journal of Anatomy and Physiology*, 1871). However it be, iron is largely eliminated in that secretion, but any amount that passes through the intestine is liable to be changed into tannate or sulphide, and so to color blackish the fecal mass; if this be of ordinary consistence, its external surface, which is alkaline, will be found more deeply stained than the inner part, which is slightly acid (Quevenne). In suckling children, the coloration will not occur, and if the salt be very completely absorbed, as are small doses of proto-chloride (Rabuteau), or of tartrate (Stillé), it will not be noticed for some days, or until the system is saturated. Again, if the iron pass without any assimilation, it is also said not to color the stools, so that this effect has been considered, though I believe incorrectly, some guide to the absorption of the drug (Kraus, in Ranking, i., 1872, p. 272).

Physiological Action (External).—Compounds of iron with the mineral acids act as caustics, irritants, or simple astringents, according to the kind and strength of preparation used; they are also, to some extent, antiseptic. A caustic, destructive action is exerted by the solid perchloride, especially upon raw surfaces or mucous membranes, but it is not so deep or thorough as that of the mineral acids alone, because of the rapid coagulation of albumen. The astringent effect of dilute prepara-

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tions is explained partly by such coagulation, and partly by the constriction of capillaries induced.

Kulischer has made curious experiments to test the comparative effects of certain astringents and hæmostatics; having divided some blood-vessels in the limbs of frogs, he stayed the bleeding with different astringents applied for various lengths of time, and then injected liquid into the larger blood-vessels, and calculated the amount of force required to reopen those that had been divided and closed; from his results he concluded that of iron solutions a strength of 30 per cent. gave the best results, and the good effect was proportioned rather to such strength than to the duration of its application (*Schmidt's Jahrb.*, Bd. clxix., 1876). Some researches by Rosenstirn upon the same subject, though conducted in a different manner, show also how much the action is dependent upon a definite strength of solution, and enable us to compare the effect of iron with that of other astringents. He examined and measured, under the microscope, the amount of contraction of blood-vessels in a frog's mesentery after application of 10 per cent. solutions of nitrate of siver, acetate of lead, and perchloride of iron, and the last acted not at all; he then used 50 per cent. solutions, and found the iron one very effective—it narrowed both veins and arteries at the place of application, arrested circulation, and acted as a true styptic on the blood itself; the adjacent vessels became dilated.

The coagulum formed in the living vessel by perchloride of iron is soluble, to some extent, in the stream of alkaline blood, and especially so if the astringent solution used be unduly weak; it is also soluble in slightly acid liquids, but is rendered more consistent by combining the iron with alkaline chlorides (Piazza: *Bulletin de Thérapeutique*, 1868). The blood-clot, with lactate of iron, is said to form more slowly, and to be more permanent.

The antiseptic powers of astringent iron preparations are connected with the coagulation of albumen, and strong solutions are fatal to the lower forms of vegetable life. Ferreil ascertained that the neutral strong solution of perchloride arrested decomposition in a blood-clot (when it had commenced), and formed with fresh blood a coagulum that remained unaltered for many months (*Union Médicale*, 1859, p. 374). Similar observations have been repeated since, but the irritant properties of the strong iron chloride preparations make them less suitable for surgical disinfectant purposes than they would otherwise be, and carbolates, sulphates, etc., have superseded them.

Physiological Action (Internal).—*Circulatory System.*—Under the ordinary use of neutral preparations of the drug, the pulse becomes more full and forcible, and the color of face and mucous membranes more florid. It is commonly said that if they be pressed beyond a certain point, symptoms of plethora and of congestion set in, as shown by flushes

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and giddiness, engorged viscera, and tendency to hemorrhage; but if the patient have good air and exercise, and moderate food, such effects are not likely to occur. The blood will not take up more than a certain amount, and will protect itself by non-absorption, rather than by elimination. Hirtz even asserts that he has never seen congestive symptoms, vertigo, etc., except from the excessive use of chalybeate waters containing carbonic acid, to which he attributed them (Nouveau Dict.).

According to Sasse and Pokrowsky, the use of iron salts increases the heart-action, and Laschkewitsch proved increased blood-pressure in animals taking even small doses (Husemann). In illustration of the effect of large doses (though complicated by alcohol), may be quoted the case of a woman who swallowed 1 oz. of the tincture of perchloride, during an excited condition; the pulse became quick and small, the eyes injected, and the face flushed; convulsive attacks occurred, but were probably hysterical; she recovered after free vomiting (Warburton: *Lancet*, i., 1869). In disease, on the other hand, there is evidence sometimes of a sedative effect on the circulation. Giacomini records a slow and feeble pulse, pallor, etc., after 20 to 40 gr. of carbonate; and Pize found it lower the pulse and quiet the circulation in purpura and chlorosis, when accompanied with palpitation; in the former case, some gastric irritation was probably caused; in the latter, good effects resulted probably from improved blood-condition. I have known the acetate quiet the circulation when the perchloride did not do so.

Action on Blood.—According to Nasse, there exists in 1,000 parts of blood, 0.832 of iron oxide. Hæmoglobin contains 0.42 per cent. as a constant quantity; most of it is in direct organic union with the red corpuscles, in the proportion of about 1 part of iron to every 230 (Gorup Besanez); when dried, they contain seven times as much as the fibrine, and four times as much as the serum (Boussingault). Being required then for the normal constitution of red blood, iron is essentially a *food*, but since illness follows deficiency in the number or quantity of corpuscles, and iron in substance will often remedy such illness, it equally comes within our province as a *medicine*, and from its curative effects, we may, inverting the general rule, deduce some part of its physiological action. That it can increase the number of red corpuscles is shown by the observations, *e.g.*, of Rabuteau, who counted them by Malassez's method, in a case of chlorosis before and after twenty days' treatment by protochloride of iron: he found the number in a cubic millimetre to be nearly doubled (*Gazette des Hôpitaux*, January, 1875); and in a specimen analyzed by Prof. Simon, the globulin and hæmatin were more than trebled ("Animal Chemistry," Sydenham Society). I need not multiply examples of this fact (though it has been denied), but there is something further to be learnt from the recent and careful observations of Hayem, on the blood of anæmic persons (*Comptes Rendus*, 1876, p. 985). He found that in cases of

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moderate chlorosis, the *number* of corpuscles was not markedly less than normal, but they were altered in shape and size, apparently in consistence, but most markedly in *color-power*, so that a given quantity showed a red tint not deeper than that of half the number of normal corpuscles. Further, after a course of iron, the number of corpuscles in the same patient was not always increased, sometimes it was diminished, but then the corpuscles individually had grown larger and of normal shape, and of so good a color as to equal even a greater number of the ordinary kind; he concludes then that iron acts by improving the internal nutrition of the globules, "it solicits them" to take up more hæmatin, more coloring matter. These observations confirm the older ones of Le Canu (Thèse, 1847), that iron is the main constituent of hæmatin, is inseparable from the coloring matter, and must be at least an important element in the color itself. Hayem's conclusions are of still more importance as bearing on the assertions of Denis and of C. Bernard, that there is no real deficiency of iron in chlorotic blood, because they prove such a definite change in its *vital* characters under the medicinal use of the drug. Granted that there is no numerical, there is clearly a physical or a vital change produced by iron; and although it may be true that ordinary nutriment contains as much iron as should be wanted (Bernard), yet it seems equally true that we may sometimes have to give much that we may get a little absorbed (Gubler), that we must therefore give it "en masse," as we do, and (apart from all theory) Hayem furnishes us with a rational basis for our therapeusis. That the proportion of iron can vary in blood is proved by the analyses of Picard (*Comptes Rendus*, November, 1874); in 100 c.c. taken from three dogs respectively young, adult, and weakened by hemorrhage, he found that the amount of iron was .092, .065, and .041, and he established also the fact of a definite and constant relation between the amount of iron in any specimen of blood, and the amount of contained oxygen as liberated in vacuo from quantities of 100 c.c.

If it be asked *how* iron adds itself to the corpuscles and promotes their growth, we must recognize that it is not by mechanical addition to the formed corpuscle, or else the proportion in chlorotic blood could be at once increased, and failure to cure would not occur, nor relapse be so frequent. An observation by Quevenne throws some light upon the process; he found in proteid solutions withdrawn from the stomach of dogs more abundant precipitates of nutrient material if meat or wine, or iron especially had formed part of a meal, and suggested that in the portal vein a similar precipitate occurs (from the meeting of currents from splenic and mesenteric vessels both laden with the results of digestion in intimate contact with the added iron), that such precipitate is at least precursory to the formation of globules, and that at this stage iron exerts its blood-forming power ("Mémoire," etc.). It would seem that better corpuscles are formed when (the vital processes being fairly ac-

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tive) one of their essential constituents is presented in unusual abundance for absorption. It becomes then combined with them in some organic, rather than chemical or mechanical union; and besides such direct action in the formation of globules, iron exerts special stimulating power over the blood-glands, which power, indeed, is by Trousseau and others considered more important than the last-mentioned. Further, when even a few new corpuscles have been formed, they add fresh nerve-energy and improve digestion, and the blood-forming process becomes still more actively assisted. Iron has been variously thought to be in the corpuscles in its metallic state, as phosphorus exists in the brain (Le Canu, Mulder), or as a free phosphate (Fourcroy), or as a peroxide (Denis, Mialhe, and a majority of observers). A precise chemical theory was elaborated by Liebig, who taught its presence as peroxide on account of its reactions with sulphuric acid, and found that this hydrated peroxide, in contact with moist organic membrane in partly closed vessels, could change to a protocarbonate, and on free exposure to oxygen could change back again, with evolution of carbonic acid: so that venous blood was held to contain a protocarbonate, and recently aërated blood a peroxide. It is difficult to accept so entirely chemical a theory, which implies that the element is more loosely combined with the corpuscle—more distinct from its substance—than it can be; other difficulties are stated in physiological works, and Liebig's view, though highly ingenious, and containing no doubt a partial truth, can only be accepted as an hypothesis.

Oxidizing Power.—To the metallic element in the corpuscles has been somewhat fancifully attributed an electrical and a polarizing action, and even a power of increasing heat by mechanical friction! There is a general and better-founded opinion that it greatly aids in the conveyance of oxygen and in oxidation (a main function of the corpuscles), and some modern researches support this opinion—thus, Schönbein, quoted by Dr. A. Sasse, proved that animals without blood-corpuscles were suffocated in oxygen as much as others in nitrogen; that the gas must become changed into ozone and antozone in order to be fully efficient, and that iron, or corpuscles, will effect this change. Iodized paper is turned blue both by ferric solutions and by diluted blood, and peroxide of iron can change into protoxide and ozone. As an illustration, he quotes the spread of rust on steel, or "iron mould" on linen, the stain extending by formation of ozone, which corrodes the adjacent particles of the steel, while the reduced oxide attracts fresh oxygen from the air. Similarly, it is argued, the iron in the corpuscle continues alternately to attract and to give up oxygen, and to become a proto- or a per-salt until finally excreted (*Schmidt's Jahrb.*, v., 1865).

If iron, when taken into the system, does aid oxidation it should raise the *temperature* and increase tissue-change, but the amount of scientific evidence on the subject is unfortunately small. The observations of W.

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Pokrowsky, though valuable and often quoted, were made on patients seriously ill and recently removed to hospitals, and seem scarcely sufficient for the conclusions drawn from them. In five out of six cases the temperature was slightly raised; in one (a case of phthisis with hæmoptysis, taking small doses of tinctura ferri) it was lowered; the pulse was either changed or slightly increased, the elimination of urea was augmented, and weight was gained. In one case the rise of temperature followed within five hours of the dose, and it occurred equally in the cases where temperature was previously normal. It should be noted that the syrup of iodide of iron was chiefly used, and the iodine must be allowed for as influencing tissue-change; also that Pokrowsky himself, while recording improved nutrition, traces it only to "improved tone of capillary vessels," not to increased oxidation (Virchow's *Archiv*, Bd. xxii., v. 6); he states that he acted as a student under Dr. Botkin. I find no reference to other observations by the latter upon healthy men, as mentioned by Sasse.

Some recent analyses by Rabuteau would seem to support the supposition of increased oxidation, but they refer only to the renal secretion; comparing the results of five days when taking daily 12 ctgr. of perchloride of iron with the same period, on the same diet, but without the iron, he concluded that it did not affect the quantity of his urine, but augmented its acidity and its solid constituents and urea (10 per cent.). Phosphoric acid was lessened, as it usually is, under cod-liver oil and other restoratives.

The researches of Picard (*v.* p. 143) proving a definite ratio between the amount of iron and of oxygen contained in the blood, are of importance in this connection, and it is an axiom that iron preparations exert their best curative effect when the supply of oxygen is ample; but the conclusion of Sasse—that iron can supply the place of red corpuscles as an ozonizing agent in the body can scarcely be correct; were it so, the cure of anæmia and chlorosis would be more certain than it is. We can but consider iron as an adjuvant, and as being, when in the corpuscles, subject to other than merely chemical laws.

Different Action of Proto- and Per-salts.—The important experiments of Blake, so far as they can be practically applied, would point to a marked difference between the action of proto- and per-salts on the blood and the circulation. Injecting 10 gr. of protosulphate (in solution) into the jugular vein of a dog, there occurred a quick but temporary depression of the heart-action and blood-pressure; with 28 gr. heart-action stopped, and pressure fell to zero; 70 gr., in divided doses, caused a gradual general dulness, and death from asthenia—the right cavities of the heart were distended with dark blood, the left contained 1 oz. of brighter color, but the coagulating power was lost.

When 2 gr. of persulphate, dissolved in 2 oz. of water, were injected into the same vessel, pressure was diminished for a brief time, but quickly

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rose again when 3 gr. more were given; death soon followed; the left heart-cavities were empty and contracted, the right distended, the blood coagulated at once when exposed; the lungs were bright scarlet and contracted, and Dr. Blake attributed death to contraction of their capillaries preventing the supply of arterial blood to the left heart. Five grains thrown into the axillary artery raised the blood-pressure at once from 6 to 12 degrees (by the hæmadynamometer); death followed, and both sides of the heart contained dark blood, implying that the lung-contraction was overcome in this instance, but only by an extreme degree of pressure. The obstruction of the lung-capillaries might be caused by a physical change in the blood, rather than by contraction of the vessels, but the quantity seems too small for the former effect, and an analogous contraction of vessels is produced by digitalis, which proves its possibility.

The general results of the experiments go to demonstrate that *proto-salts* lower cardiac irritability, and in toxic doses arrest heart-action, cause slow respiration, sedation of nerve-system, and death by depression: *per-salts*, on the other hand, have no direct action on the heart, certainly do not lessen its irritability; they cause symptoms of pressure on the nerve-centres, and death through interference with the pulmonary circulation, cutting off the supply to the left heart. Collaterally, it is argued that proto-salts cannot be readily oxidized in the blood, or else some "peroxide-effects" would be developed from 70 gr. of a proto-salt; and that per-salts are not readily reduced, or the effects of such small quantities would not be so persistent (*Journal of Anatomy and Physiology*, 1869), but reviewing all the experiments and conclusions, we must doubt whether the mechanical forcing of substances into the blood-current can be held to compare with natural absorption and assimilation. The difference, however, exerted by the two classes of salts upon coagulation, has an important bearing upon their use for local injections, on the formation and solution of clot, on embolism, etc.

Digestive System.—Most of the soluble salts of iron have an inky astringent taste, and by continued use, stain the teeth and mouth of a dark color (tannate of iron). Compounds with a mineral acid exert a local astringent action on the mouth and stomach, and if the dose be small and diluted, may improve the tone and the functional power of the gastric membrane: but these, or any other preparation, if given in undue quantity, may irritate, and cause indigestion (from lessened secretion), with sense of weight, nausea, or diarrhœa.

Quevenne experimented with gastric fluid withdrawn through a fistula from the stomach of dogs, and judged of the effects of iron on digestion by the precipitates of peptones obtained from the fluid at certain periods after a meal. There was less precipitate when the juice was acid than when partly neutralized, but he concluded that various forms of iron, given

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with food, improved the character and amount of the precipitate: they did not increase the proportion of pepsine, nor alter the duration of the digestive process, but were quite readily absorbed, and the dogs thrived and gained flesh under their use. On the other hand, when given without food, and especially in the metallic form, iron did not stimulate the formation of sufficient secretion to dissolve itself, but acted as a foreign body, and impaired digestion: 10 to 20 gr. of reduced iron would cause diarrhœa, hence a reason for the ordinary rule of ordering iron preparations at the time of a meal, and in small doses (2 to 3 gr.). The sulphate and chloride of iron have sometimes, by mistake or for criminal purposes, been taken in large quantities (1 oz. and upward), and have caused violent pain and vomiting, with other symptoms of irritant poisoning, and gastro-enteritis, but have rarely proved fatal (Taylor).

Secretion.—Astringent preparations will usually lessen the secretions, especially those of the gastro-intestinal tract. Upon the kidney, in health, the effect as to quantity of secretion is not much, but some irritation of the bladder and the urinary tract may lead to increased frequency of micturition. In some persons, however, and in some diseases, iron preparations, especially the tincture of the chloride, the citrate, and the tartrate, have proved good diuretics, directly or indirectly: the tincture, in fact, is termed by Simpson a "renal purgative" when recommending it in "surgical fever" (*Medical Times*, i., 1859, p. 517). The secretion of milk has diminished or ceased in cows drinking a ferruginous water, and in some suckling women taking a course of iron (Martin); Bistrow records a similar result in a goat under the use of lactate of iron: on the other hand, there is clinical evidence that non-astringent preparations taken by anæmic women during lactation will improve the secretion as well as the general health (Routh: *Medical Times*, i., 1859). The effect is clearly that of a restorative, and as we find so often in the use of iron, it will vary with the preparation and the patient taking it.

Generative System.—From an early period iron has had the repute of specially stimulating this system. A classical cure of impotence by iron-rust among the Argonauts is commonly quoted, and we may rescue from oblivion the curious marriage-contract said to be common at one time among the burghers of Frankfort, to the effect that their wives should not visit the iron springs of Schwalbach more than twice in their lives, for fear of being too fruitful (Dr. Jacques, Thèse, Paris, 1843). There is clinical evidence of its value in sexual debility, and in derangement or suppression of the ovarian function, but it seems more explicable by a general tonic and hæmatinic power than by a special local action, though Trousseau attributes to iron aphrodisiac power. The tincture of the chloride is in somewhat common use as a supposed abortifacient. Taylor regards it as a dangerous drug for pregnant women, but his examples scarcely corroborate this, and the clinical evidence and experience

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as to medicinal doses mentioned later on (*v.* p. 173) tend to an opposite conclusion. We may recognize, however, that very large doses of astringent preparations are not safe—they may injure by general irritation or local congestion, as shown in some cases reported in *Medical Times*, ii., 1860, p. 84.

SYNERGISTS.—Manganese, and most tonics and acids: as astringent, ergot, turpentine, etc.

ANTAGONISTS—INCOMPATIBLES.—Weakening and fluidifying agents such as alkalies and mercurials: the former are also, together with sulphur and tannin, chemically incompatible with most iron preparations. Gubler mentions nicotine as antagonistic.

THERAPEUTICAL ACTION—(EXTERNAL AND INTERNAL).—In this instance I find it undesirable to separate the external from the internal application of the remedy, for they are very closely connected, and if one set of observers prefer the one in any particular form of disease, parallel observations will be found in favor of the other; thus it is as regards hemorrhage, diphtheria, erysipelas, and even varix.

Iron in the metallic form was in early use as an astringent and roborant, though we note the absence of any mention of it in Hippocrates. In extraordinary demand at the early part of the last century, as a secret remedy, and under the name of "Elixir d'Or," "Gouttes d'Or," "Teinture de Bestuchef," etc., the perchloride solution with ether was priced at a golden louis per ½ oz., procured pensions and promotions for its makers, and served as a present for sovereigns; but when its last patentee revealed the secret, "for fear his death should lose it to the world," and when Catherine of Russia purchased the precious recipe for many thousand rubles, and presenting it to the St. Petersburg College of Medicine allowed it to be published (1780), this remedy which had been held to cure "gout and epilepsy, cramps and paralysis, rheumatism and hypochondriasis," sank into an obscurity as little deserved as was its previous reputation. Bayle, whose treatise is an excellent epitome of the therapeutical knowledge of his time, mentions only the metal and the carbonate as remedies in neuralgia and chlorosis (*Biblio. de Thérap.*, iv., 1837), and the use of soluble ferric compounds—a use so frequent and so valuable in modern practice that we may wonder how our predecessors fared without it—dates really from about 1850.

Hemorrhage.—The astringent compounds of iron with a mineral acid are excellent local styptics in all forms of capillary hemorrhage, such as from leech-bites, wounded gums, hemorrhoids, bleeding from the nose, etc. The part should be thoroughly cleansed from clot, and then a plug or compress moistened with the solution should be firmly pressed upon it, or in cavities an injection (diluted) may suffice. Sir James Simpson strongly commended a solution of the perchloride in glycerin, used it freely for all forms of hemorrhage, and with special success in some se-

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vere cases of bleeding from the vagina and uterus (*Medical Times*, i., 1858, p. 79). Demarquay, Lallemand, and Deleau were using the same hæmostatic with great advantage in France about the same time (*Gazette des Hôpitaux*, 1858–59).

The liquor ferri perchloridi fortior (British Pharmacopœia) is quite serviceable for the purpose, but is more acid, and proves often more irritating than need be, and may be well diluted with an equal part of water or glycerin. The liquor ferri sulphatis is preferred by many surgeons, and by others the liquor ferri subsulphatis, or Monsel's solution [1] of the U. S. Pharmacopœia; this is made with sulphate of iron, sulphuric and nitric acids, and is much less caustic and irritant than our solution; it is used in rectal hemorrhage—1 part to 4 of water (Allingham: *Lancet*, i., 1874)—and the "hæmostatic cotton" used by Marion Sims is prepared with it. The so-called "iron alum" is probably an equally effective preparation.

Tonsillar Hemorrhage— Wounds.—Wetherby, of New York, records a very severe case of bleeding from the tonsil (cases which are specially anxious ones, on account of the proximity of the carotid) completely controlled by the application of Monsel's solution (Ranking, ii., 1866); and I have seen instances in which a large vessel must have been wounded by an incision in the tonsil, effectively treated by the local use of tincture of the perchloride; it should always be tried before more serious measures are commenced. As styptic applications to the bleeding surfaces of wounds, iron compounds are not so suitable as some others, because they necessarily prevent union by "the first intention," and they leave a coagulum, on the separation of which hemorrhage is apt to recur. Maisonneuve, however, performed some of his boldest and most brillant operations with their help; thus, he removed a growth occupying half the face and head, and involving numerous vessels, applying perchloride on pledgets of charpie at almost every stroke of the knife, and so that the weakened boy lost but little blood; a brown eschar formed, and separated about the twentieth day (*Medico-Chirurgical Review*, ii., 1856). Bourgade applied perchloride to the bleeding surface immediately after all operations—calculating to render them by this means "as painless and as safe as if caustic had been used instead of the knife"—and to prevent septicæmia; the application was painful for a few hours, but not much pus formed, and granulation occurred in a healthy manner. He reports ninety-five cases (*Union Médicale*, 1867, No. 104). The perchloride is still thus used sometimes in operating upon soft tissues in anæmic subjects when hemorrhage is likely to be serious. I have seen it applied in the removal of a cancerous tongue and of a cancerous breast, and also

[1] The original Monsel's solution was made with persulphate, as described by him (Recueil des Memoires, t. xvii., 1856, quoted by Buisson).

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in a thigh-amputation, and in each case secondary hemorrhage occurred, and I was not at all satisfied with the action of the styptic; further, it is not free from risk of causing embolism.

Hæmoptysis.—In various forms of hæmoptysis, phthisical and otherwise, preparations of iron are useful if active febrile reaction is not present. For internal use I prefer the acetate, or sometimes the sulphate, to other preparations, and they are especially indicated in the passive hemorrhage of anæmic weakly subjects (of the acetate, I give the tincture in 5 to 20-min. doses every half-hour to two hours). Caution is needed as to their internal use in phthisis (*v.* p. 173), but their local use in spray or powder is advisable whenever the loss is severe or alarming. A striking case, in which death seemed imminent, and in which the insufflation of powdered sulphate at once and permanently controlled the bleeding, is given by Wetherby (Ranking, ii., 1866). Brondgeest (Brussels) treated successfully three phthisical cases by an atomized spray containing the chloride (*Bulletin de Thérapeutique*, 1866, t. lxxii.), and Cornil has related similar results.

I have treated several severe cases with satisfactory results by an "iron spray" containing either ¼ part of liquor ferri perchloridi, or 1 to 2 gr. of sulphate in the ounce of glycerin and water. It might be thought that blood thus coagulated *in situ* would increase a tendency to lung-congestion or chronic pneumonic phthisis, but practically I have not found it do so.

Epistaxis.—When this occurs frequently in patients already anæmic, or when the amount of blood lost threatens to bring on anæmia, iron will be found of great value, and especially in the form of acetate or perchloride: it should be commenced as soon as possible, while the hemorrhage is going on, and continued for some time after it ceases. I have seen this treatment useful in the severe epistaxis of habitual drunkards; it is not, however, always safe for epistaxis occurring in the old, or those disposed to apoplexy.

Hæmatemesis.—I have frequently treated this form of hemorrhage successfully by means of the perchloride of iron given internally; it has a direct local styptic effect, and in some aggravated cases, when the hemorrhage has occurred frequently, it has arrested it at the time, apparently prevented relapse, and certainly lessened after ill-effects, such as anæmia. In recent acute cases, ipecacuanha powder in doses of 1 or 2 gr. is more efficacious, but in semi-acute cases it is well to alternate this remedy (every half-hour to every two or three hours) with 15 to 30 min. of the iron tincture in water. I have known this method check severe hemorrhage in a case of gastric ulceration, after other remedies had failed, and Mr. Bowles records similar instances: he used 1 dr. of the tincture in 1 oz. of water, giving it after the stomach had been emptied by emesis, so that it could directly reach the bleeding part (*British Medical Journal*,

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i., 1872). Deleau, Pleischl, and others have also recorded excellent results from this treatment (*Medical Times*, i., 1857, *Medico-Chirurgical Review*, 1859), and it might with advantage be more generally adopted. Iron alum (a double sulphate of iron and ammonia) is also very valuable in this and other forms of internal hemorrhage (*Lancet*, i., 1871, p. 806).

Intestinal Hemorrhage.—Perchloride is often useful in hemorrhage from the bowel, and I have known it answer well. Several cases, somewhat obscure in character, but recovering under perchloride, are given in *Bulletin de Thérapeutique*, 1877. The ordinary cause of such hemorrhage would be either cirrhosis of the liver or ulceration, and I do not think iron suitable for the former condition, but in the latter it is more indicated, since we know that it relieves hemorrhage from gastric ulcer. In the diarrhœa and hemorrhage of enteric fever, benefit has commonly been derived from its use. Dr. Russell Reynolds has used the perchloride (*Medical Times*, i., 1867, p. 32), and Dr. Broadbent the sulphate in enteric fever (*British Medical Journal*, ii., 1869), but I have not met with any published conclusions as to the value of these remedies. "Iron alum" I should myself prefer as a styptic in such cases.

Hæmaturia.—The internal administration of perchloride of iron is not desirable in acute renal congestion, but I have occasionally met with chronic recurrent hemorrhage, apparently from the kidney, the subjects of which were anæmic and suffering from chilliness, nausea, faintness, etc., and who received much benefit from the perchloride. The dose should be from 15 to 30 min. every six hours, and its efficacy may often be increased by 2-gr. doses of ipecacuanha powder, given midway between. A very successful case illustrative of treatment by perchloride is reported by Vigla (*Gazette des Hôpitaux*, 1858). In urethral and vesical bleeding the same treatment is very serviceable, and in the latter malady iron injections into the bladder have been employed with advantage, but the solution must be weak, for if rapid and solid coagulation of blood within the viscus were produced, the effects might be worse than those of the hemorrhage itself.

Purpura—Scorbutus.—Iron has sometimes succeeded well in purpura of passive character, but is not of much advantage in the bleeding of true scorbutus. Both the sulphate and the perchloride have cured cases when other remedies, such as sulphuric acid and change of diet, have had no effect. Homolle was the first physician to recommend the sulphate (*Union Médicale*, No. 135, 1856), and Dauvergne, recording a striking instance of benefit from the perchloride, remarks that it acts better in cases with large effusion (in plagues) than in the merely petechial forms, and this I believe from my own experience to be correct (*Bulletin de Thérapeutique*, 1867). Other cases may be found in *Bulletin*, 1868, *British and Foreign Review*, i., 1861, and *Medical Times*, ii., 1861, p. 501; they include one patient at seventy, and one a child; in one the malady

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was connected with deficient supply of animal food; the *arseniate* answered well in another case (*Lancet*, ii., 1872).

Uterine Hemorrhage.—All cases of uterine hemorrhage must be carefully considered from every point of view, before resorting to medicinal or local styptic treatment. In a large number of such cases iron is highly useful, but it must not prevent the proper manual and surgical management of, for instance, retained placenta or fibroid growth, nor the depletive treatment of a congested uterus. In menorrhagia occurring in the young or the delicate, and accompanied with a general lax anæmic condition, and often with intercurrent leucorrhœa, the sulphate or perchloride are suitable as internal medicines; the former, with sulphate of magnesia, is especially good. The excessive loss, as well as other and general symptoms which often occur at the climacteric period, may be also relieved by these remedies.

Uterine Cancer, etc.—Simpson knew the value of perchloride in relieving the hemorrhage and discharge of cancer, and French surgeons equally proved it. The liq. ferri fort. is exceedingly serviceable, as shown in a good paper by Dr. Gibb, of Newcastle; he either filled the vagina with a dilute solution for a few minutes, or plugged with tampons, or painted the strong liquor on the affected part, and so far relieved bleeding and pain, and improved the local condition, as to give, at least, a period of comfort (*Lancet*, ii., 1874, p. 830). I have myself used the same application with excellent results, and my colleague Dr. Potter constantly uses in cancerous cases a plug of lint or cotton wool soaked in a solution of liquor ferri perchlor. fortior and glycerin (equal parts), and firmly pressed against the uterine surface, the vagina being filled with wool soaked in glycerin. Another method is to apply the saturated solution of perchloride to the affected surface on a Playfair's uterine probe wrapped with cotton wool; this is best in cases when the vagina will not tolerate the presence of tampons.

In cancer other than uterine its application is also valued by myself and many observers independently of its power as a hæmostatic: it constringes and modifies the affected surfaces, inducing a less rapid growth. Iron cannot cure cancer, but the debility and the anæmia dependent upon it may be much relieved by a course of it.

Villous Growth.—A severe and obstinate menorrhagia, dependent on this cause, was successfully treated by Breslau with an intra-uterine injection of equal parts of liquor ferri (Bavarian) and water; it was made through a catheter, left only one minute and then withdrawn (1858). This was one of the earliest cases of the kind, and illustrates a method which I have several times employed with advantage; but a more modern and often curative practice is to scrape the surface of the lining membrane with a curette.

Fibroid Tumor.—If the patient is suffering from marked anæmia and

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from continued loss when she first applies for advice, considerable relief to the symptom may be given for a time by the internal administration of the perchloride, especially when combined with ergot; it may possibly be required as a styptic to the cut surface after incision of the cervix; in cases of emergency, plugging of the vagina with saturated tampons is a valuable temporary resource.

Puerperal Hemorrhage.—The local application of so excellent a remedy has not been neglected in this—perhaps the most anxious form of hemorrhage with which we have to deal. Sometimes the use of plugs or tampons steeped in the solution, and packed in the vagina, has seemed the best mode of treatment, but it is not free from risk, for it may only conceal serious internal hemorrhage, and moreover, the prolonged contact of strong preparations, even though at the time painless, has been followed by serious loss of substance, and permanent contraction and cicatrix (*Gazette des Hôpitaux*, 1869, No. 113). In post-partum hemorrhage, the rapid application of a saturated sponge to the interior of a non-contracting uterus has proved efficient (Barnes), but the contact of a strong solution so quickly corrugates the membrane of the vagina and the os uteri, as to cause difficulty in carrying the instrument far enough, or in withdrawing it (Braxton Hicks, Norris).

Intra-uterine Injections.—Few surgical procedures have more widely and earnestly engaged professional attention of late years than the intra-uterine injection of strong ferric solutions. Schreier, of Hamburg, was accustomed to use weak injections (½ to 1 dr. in 4 oz. water) for hemorrhage, either before or after delivery (*Medical Times*, ii., 1855), and still weaker injections (1 dr. to the pint) have long been practised in the Vienna school, if cold and ergot failed. Ford recorded the successful arrest of severe hemorrhage after abortion by intra-uterine injection of ferric sulphate (1 dr. in 4 oz. water), also three other cases (*American Journal*, April, 1868). Probably other instances might be found, but general interest in the subject was first thoroughly aroused by Dr. Barnes. The mode adopted by him was to mix ½ pint of the liq. ferri perchlor. fort., B. P., with water up to 1 quart, and to inject this slowly through a Higginson's syringe, of which the delivery pipe was passed well to the fundus uteri; by this plan he was satisfied that life had been saved several times, and he held it specially applicable to cases when contractile power could not be roused, and the uterus remained dilated and inert after a prolonged labor. The styptic mechanically stayed the hemorrhage by sealing the vessels, and usually induced also uterine contraction (*Medical Times*, i., 1865; also *Lancet*, i., 1869, and *British Medical Journal*, ii., 1873). Dr. Hugh Norris (Somerset) recorded a similar experience about the same time (*British Medical Journal*, 1869–70). Cases for and against were soon reported from different parts of the country, and it was not long before a vehement controversy arose, tinged, unfortunately, with

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some personal animus. A case of secondary hemorrhage really dependent upon retained placenta, but in which several injections of perchloride solution (the last one being of the strong and undiluted tincture) had been practised, died ultimately of septicæmia, and furnished the text for a full discussion at the Obstetrical Society. Such a case was not really illustrative of Dr. Barnes' mode of treatment, and, although it proved fatal, the opinion of practical and experienced accoucheurs such as Braxton Hicks, Playfair, Potter, Edis, Murray, etc., was expressed decidedly in favor of such injections in suitable cases (*Lancet*, i., 1873, pp. 306, 407). On the other hand, Graily Hewitt, Routh, Bantock, and Snow Beck, referred to other instances in which such injections did apparently cause septicæmia and embolism. In Dublin, the favorable experience of Dr. Barnes was amply corroborated by Dr. Lombe Athill, while Dr. E. Kennedy took a much more cautious view, and urged the reservation of the method for a *dernier ressort* (*Dublin Journal of Medical Science*, May, 1874).

In Edinburgh, the discussion of an unsuccessful case showed a balance of opinion against the procedure. Dr. Mathews Duncan especially questioned its propriety, though Dr. Alexander Simpson expressed a more favorable view (*Edinburgh Medical Journal*, February, 1875). In France, if we may judge by the observations of M. Budin, of the Maternité, professional opinion is decidedly adverse (*Bulletin de Thérapeutique*, 1876, p. 89). In Germany ferric injections seem to have been scarcely tried, for no account of them is to be found in the *Archiv*, *Zeitschrift*, *Centralblatt für Gynæcologie*, nor any comments on German cases in Schmidt or Virchow and Hersch *Jahrsbericht*.

An impartial estimate of English writings on the subject leads to the conclusion that the greater part of the favorable testimony comes from those who have really used the method of Dr. Barnes, while objections are made chiefly by those who have not ventured to try it. The latter urge (1) that the proper object in the treatment of post-partum hemorrhage is to secure uterine contraction (not simply a plugging of the vessels with clot), and that cold, friction, etc., are better and safer agents for the purpose; (2) that there is too great tendency to neglect these measures for the more energetic iron treatment; and (3), which is most important, that such treatment exposes the patient to grave risk from the formation of emboli or the injection of air into veins, or the forcing of fluid through the Fallopian tubes. The first objection as to uterine contraction is met by the statement that highly experienced men have, in some instances, failed to secure uterine contraction by any ordinary means, and have succeeded with the ferric injection, and have thus stayed severe hemorrhage, and probably saved life, without any ill-result; but much weight must be allowed to the other objections. It is within my own experience that iron injections have sometimes been employed far

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too soon, from over-anxiety to stay what I should consider not excessive hemorrhage, and which would have yielded, I believe, to cold and the judicious use of ergot. I am also cognizant of at least five cases in which death has followed apparently from embolism, and yet I do not blame the principle of the treatment so much as some defect in carrying it out. Thus, sometimes the uterus has not been properly emptied of clot beforehand; sometimes the solution has not been strong enough, and at other times the exit has not been free. The greatest care is required as to all these points. The patient should be on her back, the womb emptied of clot and gently compressed, the uterine tube should be long enough (about 9 in.) to reach to the fundus, the solution should be of about 2 oz. dry perchloride to 12 oz. water, or 2 oz. liquor ferri perchloridi fort. to 10 oz. water, free from air, and injected slowly and steadily, and the os must be patulous, and the exit quite free, so that no undue pressure or distention should force fluid into vessels or through the Fallopian tubes. If these precautions be all adopted, I believe the ferric injections may be used with safety and with the best results, even in most serious cases; they are an important addition to our means of saving life, but of late years the injection of *hot* water into the uterus has been found to be as efficacious as solution of iron and devoid of its dangers, and promises to entirely replace it in practice.

Injections in Aneurism, etc.—In 1852 Pravaz, of Lyons, excited the utmost interest by his discovery of the coagulating powers of ferric perchloride, its effects when injected into the vessels of animals, and its successful use in various forms of aneurism. His observations were confirmed and extended by Giraldés, Broca, and others, who formulated rules for securing a good and firm clot, and obviating the dangers of inflammation and embolism which were soon found to be involved. The greatest importance was attached to the purity and neutrality of the preparation, its due density and proportioned amount to the size of the aneurism, and to the securing of pressure on the vessel above and below the seat of operation. Five drops of an aqueous solution at 30° density (Beaumé)=1.261 sp. gr., or 10 drops at 20° (1.160), was the calculation for each cubic centimetre (15 gr.) of blood to be acted upon (Giraldés). Dieulafoy has calculated even less than this. If too strong a solution, as of 45° to 50° (Beaumé) =sp. gr. 1.449 to 1.526, be used, the vascular coats may become inflamed or gangrenous, and, if compression be omitted, embolism certainly may occur; and it will be found that some fault in these respects would explain most of the serious and fatal results which excited the vehement opposition of Malgaigne and others to the new procedure.

I think that scarcely sufficient importance has been attached to some of the successful cases—notably to one of aneurismal tumor of the orbit—recorded by an American surgeon (Brainard: *Lancet*, ii., 1853). The

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ligature of one carotid had given only temporary relief, and the actual cautery still less, but a complete cure resulted from several injections of the lactate of iron (8 gr. to 1 dr.). Brainard considered this salt more suitable than the perchloride, as acting more slowly, and with less irritation or tendency to suppuration. Bribosia (Brussels), in a special treatise on the use of coagulant injections, considers them best adapted for such aneurisms as contain more liquid blood than fibrine, and are situated on the smaller arteries (*e.g.*, those of the cranium), and not too near the trunk. It must be acknowledged, however, that the general opinion of modern surgeons is adverse to the use of the perchloride as a coagulant in aneurism: Mr. Hart points out that compression of the affected vessel above and below the sac is a *sine quâ non*, and when this can be obtained usually safer methods of treatment may be employed ("Holmes' System," vol. iii., 2d Ed., 1870). Marsacci, in a recent work, came to the same conclusion; Gross and Erichsen also discourage it, though the latter speaks of curing with it a gluteal aneurism after some suppuration ("Science and Art of Surgery").

Nævus—Erectile Tumor.—The application of ferric injections to these cases, though often successful, was soon found to require as much caution as in the more serious malady of aneurism. Thirty drops of the tincture injected into a nævus of the scalp caused erysipelas and sloughing before cure resulted (*Medical Times*, ii., 1853); in a few cases, situated about the face, immediate death resulted, this being sometimes clearly due to a clot formed in a large vein (*Archives de Médécine*, November, 1868; *Lancet*, ii., 1867). In a few other cases cerebral embolism and softening or pyæmia followed (*Lancet*, i., 1874; *Bulletin de Thérapeutique*, 1873). On the other hand, Mr. Cooper Forster had good success after dividing the nævus-tissue subcutaneously and then injecting a "few drops" (*Medical Times*, 1853, p. 654). Mr. Morgan made an excellent cure of a large erectile tumor of scalp, using circular compression by plaster and pasteboard; and other good results might be adduced, and, with very great care, might, I believe, be still obtained, but by common consent the operation has been discontinued on account of its danger (G. Buchanan: "Lecture," *Braithwaite*, ii., 1875). A recent Paris thesis, however, re-directs attention to the subject, and presents it in a favorable light (Auguste Rigaud: Thèse, Paris, 1876).

Another and a safer method of using the perchloride in nævus is described by Leclerc, who applied it on pledgets of lint to the part, and obtained a cure at the expense of some erythema and suppuration. Guillot used it after first destroying the epidermis with caustic potash, and Guersant after vesication (*Bulletin de Thérapeutique*, t. lxvii.).

Varix.—Varices, without pain or ulceration, should seldom be interfered with by external treatment; but I have frequently known a very marked improvement in them while patients were under a regular course

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of 15 to 30 min. of the perchloride of iron, three times a day, for other affections. To judge by the recorded results of iron injections in varix, a large amount of success has been obtained with much less risk than in the last-named diseases; but yet the method is not generally approved by most modern authorities. Minor reports five good cases in which either the scrotum or the legs were affected, and three or four drops of a solution of persulphate (1 part in 4 of water) were sufficient for cure; the patient was in the upright position, and pressure was carefully applied above and below the seat of puncture (Ranking, ii., 1860). Sentoux, collecting 126 cases, found 100 cured, 19 relieved, 6 unaffected, and only 1 death. Denucé reports many successful cases (*Moniteur des Sciences Médicales*, November 15, 1862; *British and Foreign Review*, April, 1862); the perchloride was used with certain precautions. Desgranges thought the method, with ordinary care, to be free from danger—2 drops sufficed for the largest varicose lobule. He notes the improvement in varicose ulcers after the operation (Abstract: *British and Foreign Review*, ii., 1858). Morgan, of Dublin, succeeded in obliterating part of the saphena vein by injecting 5 drops of Monsel's solution in two places, carefully isolated: coagulum formed in fifteen minutes, and the case did well; in another, with irregular dilatation, and large varicose clusters about the knee, the same method of injection above and below was equally successful (*Medical Press*, July 14, 1869). Brainard's experiments on the formation of clot in veins under the use of sulphate were very satisfactory (loc. cit); and Gross, speaking of nævus, and discouraging the use of perchloride, yet says that by "Monsel's solution any case of arterial or venous tumor, unless very bulky, may generally be promptly and effectually cured" ("System of Surgery"); this would seem sufficient to warrant a further trial.

Hæmorrhoids.—The perchloride is not only frequently of service as a styptic injection into the rectum to relieve bleeding from internal hæmorrhoids, but has been used sometimes by direct injection into the tumors, and has cured when other expedients have failed (Colles: *Dublin Journal*, June, 1874). Monsel's solution succeeded equally well in two cases of large external piles under Mr. Morgan (*Medical Press*, 1869). Hæmorrhoids occurring in anæmic or debilitated patients with copious bleeding, are in my experience often well treated by the internal administration of the perchloride.

Relaxed and Discharging Surfaces—Relaxed Throat, etc.—The liquor ferri perchloridi, with a little glycerin added, is a good astringent locally and internally in catarrhal sore throat, and in relaxed conditions of fauces with mucous secretion: also in the œdematous, honey-combed condition which remains after follicular tonsillitis, or more serious throat inflammations.

Leucorrhœa.—In catarrhal and relaxed conditions of the vaginal mu-

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cous membrane, injections containing about 1 dr. of the tincture, or 10 gr. of sulphate of iron in each ½ pint of water, are often useful, but they have the drawback of staining linen. When the leucorrhœa is mainly dependent upon general debility, the internal administration of iron is often sufficient to relieve, without any injection; and in severe cases, occurring in anæmic and cachectic females with œdematous swelling (from excessive blood-losses), I have found the citrate of iron and quinine useful. Montgomery commonly recommended the pernitrate for leucorrhœa.

Gonorrhœa.—In the chronic stages of urethral inflammation, sulphate of iron forms a good injection. I recommend about 12 gr. with ½ oz. of laudanum, in 8 or 10 oz. of water—a little to be used three times a day; another form, recommended by Dr. Ringer, contains ½ dr. of the perchloride tincture, with 1 dr. of laudanum in ½ pint water. "It often speedily checks the discharge, and relieves pain on micturition." Barudel, writing from a large experience, would absolutely restrict the local use of perchloride to chronic cases, but he advocates it *internally* for all forms of urethritis, acute and chronic (*Medico-Chirurgical Review*, i., 1859, p. 244). I would not myself recommend its use, even *internally*, in acute stages, but in the later ones of gonorrhœa, or gleet, full doses of 10 to 15 min. are of real advantage. Pereira recommended the remedy in combination with tincture of cantharides.

Phagedænic Ulceration.—The combined internal and external use of tinct. ferri perchloridi is advised by Ricord (*Medical Times*, i., 1859). Roget adduced instances of it curing chancre when applied early, and he maintained that the local use of an acid solution directly after exposure would prevent gonorrhœal, and even syphilitic contagion ("Traité sur le Perchlorure de Fer," 1860, Paris). Rabuteau speaks favorably of the remedy—substituting only citric acid for the more irritant hydrochloric. He adopts the following formula—℞. Tinct. ferri perchloridi (30° Beaume, =0.879 sp. gr.), 12 grammes; acidi citrici, 4 grammes; aquæ, 24 grammes: solve f. lotio.

Spermatorrhœa.—For seminal losses occurring in the young and debilitated, tincture of iron is of great use; it should be given in full doses twice daily, and preferably not at night; plenty of outdoor exercise should be conjoined with its use.

Enuresis.—When this occurs in scrofulous children, or in those affected with worms, the perchloride or phosphate of iron gives ready help. One teaspoonful of Parrish's food, twice daily, in water, is an excellent remedy for the nocturnal as well as the diurnal form when arising from irritability of the mucous membrane of the bladder. The alternation of iron with tincture of belladonna, or bromide of potash, acts still better if there be much spasm of the sphincter, and combination with ergot has also succeeded well (Guimaud: *Bulletin de Thérapeutique*, v., 63). Da Costa strongly recommends the bromide of iron in this malady.

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Vesical Catarrh.—There can be no doubt that iron has a special determination to the mucous membrane of the urinary tract, and my own experience, as well as that of others, has proved its great value in catarrhal affections of the bladder. The carbonated iron waters of Schwalbach are especially recommended (Schmidt's *Jahrb.*, 1877, Bd. clxxiv., p. 84), and are certainly less irritant than the acid preparations. In cases of catarrh and hemorrhage, following the injudicious use of the catheter, weak injections of tinct. ferri, retained for about half a minute, check the hemorrhage and cure the catarrhal condition (*Medical Times*, ii., 1870; *see* also Hæmaturia). Other instances of the value of iron in vesical catarrh are reported by Vigla (*Medical Times*, 1857–58).

Purulent Ophthalmia.—Bathing with ferric lotions and painting with the tinct. ferri have proved useful in chronic purulent conditions of the conjunctiva, and similar treatment has sometimes dispersed corneal opacities and healed scrofulous corneal ulceration (*Gazette des Hôpitaux*, February, 1862).

Skin Diseases.—In congestive and exudative forms of skin disease much benefit may be obtained from the tincture of iron; thus, severe *pruritis* may be relieved by it (*Lancet*, ii., 1874, p. 715). In a case of chronic infiltrated *eczema*, when tarry preparations had failed, painting with the tincture, and afterwards with collodion, not only cured the intense itching, but also the malady itself, leaving only a dry and brown, but sound skin, and I have seen a case of pityriasis rubra in which the intensely red, dry, and scaly condition was more relieved by the application of this remedy combined with glycerin than by anything else. *Lichen agrius* is also relieved by it. Devergie drew attention to its value in chronic pustular disorders, such as *rupia*, *ecthyma*, and *impetigo* or pustular eczema (*Medical Times*, ii., 1860), in which it may be locally applied as well as taken internally. It is a good application for variolous pustules (*Medical Times*, ii., 1856, p. 498, Ranking, ii., 1866), and has favorably influenced the course of anthrax; a striking case is reported by Dauvergne (*Bulletin*, 1867).

Herpes.—Baudon found immediate good results from painting the vesicles of herpes with tinct. ferri perchlor, and glycerin; he recommended opening the larger vesicles for the application, but Gressy obtained equally good results without opening them, using a concentrated alcoholic solution, which gave rapid relief (*Bulletin*, t. lxiii.). An ointment containing 6 to 10 gr. of sulphate of iron in the ounce is recommended by Palmer (*Medical Times*, ii., 1861, p. 24).

Ringworm.—The local use of iron in ringworm is an old practice, which has been recently revived (*British Medical Journal*, i., 1877). After cleansing the part, tincture of perchloride may be painted upon it three or four times, at a day or two's interval; a brown scale forms, which should be left undisturbed, glycerin will lessen the sense of dryness and

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constriction. I have found this treatment succeed in slight and recent cases; also in old ones, after more active remedies had been used, and it has the advantage of being not so unpleasant as some other applications.

Onychia—In-growing Nails.—Very successful results have been obtained by using the perchloride locally; for instance, a delicate girl, who had suffered for several years and undergone removal of the nail and most ordinary modes of treatment without relief, was cured mainly by the use of an ointment made with perchloride, and a few applications of the solid compound: the latter gives pain and requires to be almost immediately washed away (*Bulletin*, 1853). The persulphate has been used in other cases (*Medical Times*, ii., 1868, p. 257).

Necrosis of Bone.—Injections of perchloride have a good effect in chronic sinuses; sometimes they act better when manganese is added (*British Medical Journal*, ii., 1871).

Ulcerations.—In chronic indolent ulceration the perchloride is a good stimulant; also the carbonate, finely powdered, has been applied in substance to old and excavated ulcers of the leg, and with good bandaging has succeeded well (*Lancet*, i., 1862). The salicylate of iron is said to make a useful lotion (*Edinburgh Medical Journal*, 1877).

Hospital Gangrene.—The perchloride and Monsel's solution have been largely used as local applications, especially in military practice. Salleron gives a very favorable report of these from experience in the Crimean hospitals and elsewhere (Buisson, "Traité," etc., and *Medico-Chirurgical Review*, ii., 1860). A "gangrenous throat" was also treated successfully with perchloride (*Medico-Chirurgical Review*, i., 1861).

Polypus—Tumor.—The perchloride has been applied, it is said successfully, to the cure of polypus nasi by injections, and by continued contact (*Boston Medical and Surgical Journal*, 1861). It has been injected also into the substance of tumors, and one case is on record when it was selected for injection into a laryngeal growth, but, a drop of the fluid escaping, sudden death followed from laryngeal spasm (*Union Médicale*, 1873).

Erysipelas.—Preparations of iron have been largely used, both externally and internally, in the treatment of this malady. A strong ointment or lotion of the sulphate (about 1 in 4) was recommended by Velpeau after many comparative trials with other remedies; it does not, however, always prevent the extension of the inflammation (*Bulletin*, 1855). Mr. Hulke recommends a lotion containing 10 gr. in the ounce (*British Medical Journal*, ii., 1871). The application of equal parts of liq. ferri and spiritus vini rect. would seem still more valuable (Oswald White, *British Medical Journal*, i., 1876); and Mr. Foster, of Leeds, obtained so much success by painting the ordinary tincture of perchloride over erysipelatous surfaces, that this plan became known as the "Leeds method;"

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it was applied also to inflamed lymphatics, breasts, etc., and seems to have been especially useful in erysipelas after vaccination (Lodge, *Medical Times*, i., 1875). Mr. Hamilton Bell was the first to publish cases of remarkable benefit from the *internal* administration of the same remedy, or rather of the old "tincture of muriate of iron;" he gave 20 to 30 drops every three hours, so that sometimes 2 oz. were taken in eight days (*Edinburgh Monthly Journal*, 1852). In severe cases of "idiopathic" erysipelas, the spread of inflammation was arrested, the pulse lowered, and the fever relieved, and equally good results were reported by Balfour, Begbie, and other eminent men; and although Lehmann writes more recently in praise of the treatment (*Lancet*, i., 1880), we cannot concede to ferrum the "specific" virtue in erysipelas that has been claimed for it, nor is it the best remedy for every case. Todd curtly denied its efficacy (*Medical Times*, i., 1860); also H. Bennet and Estlander found it useless in traumatic cases (*Medical Times*, ii., 1871).

Dr. Marshall (Dover), after relating two acute cases well cured by 20-min. doses (and purging), states that he has found the remedy of *less* use in the traumatic form (*British Medical Journal*, i., 1872). The limited experience of Parkes need not weigh with us, because his cases received only 10-min. doses or less, and were therefore not tests of the method in question; but Aran, commenting on ten satisfactory cases recorded by Mathez (Thése, Paris, 1857), points out that iron is not the best remedy for young, robust subjects with high fever.

It is fair to add that Mr. C. Bell still maintains its very great value in all forms of erysipelas, and attributes the failures of other practitioners to the use of too small doses, or of less excellent preparations; he states that under his own care patients have recovered so soon as the old "tincture of muriate" was substituted for the modern "perchloride." The former, made with sesquioxide and hydrochloric acid, contains more free chlorine and some protochloride of iron, but the present tincture of the B.P. is a more definite preparation; any difference in curative power can be ascertained only by clinical experience, and Mr. C. Bell's observations deserve attention (*Edinburgh Medical Journal*, August, 1876). Some observers have sought an indication for iron in the locality affected, finding it least useful for erysipelas of the head or trunk; but Pirrie has obtained the best results in such cases. I think that in choosing a remedy for erysipelas we should look rather to the general constitution of the patient, the nature of the tissues affected, and the character of the inflammation; thus, I find iron to be really the best remedy in anæmic, weak patients, or in lymphatic constitutions when there is rapid extension or flitting of the inflammation, when the affected surface is dark-red or bluish, when the pyrexia is slight, and when, owing to debility, the attack tends to linger.

In the erysipelas consequent on surgical operations it is also useful if

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the subject has been reduced by long-continued suppuration or other causes of exhaustion. I believe it has also some prophylactic power.

Diphtheria.—This malady is clearly allied to erysipelas, and has been successfully treated by the same preparations of iron, both locally and internally. Some of the earliest observers recommended the application of perchloride to the seat of exudation, on the ground of the effused membrane being parasitic (Jodin, Laycock), but fungus elements are not essential to diphtheria, and other physicians, regarding exudation as only one sign of constitutional infection, discouraged the use of such local means as might irritate: Trousseau, for instance, was disappointed in a strong tincture of perchloride used "as a caustic," and such application is not to be recommended; his remarks, however, do not apply to the use of a more dilute form, for blood-poisoning may occur from the affected surfaces, and I entirely agree with Dr. Heslop, Sir William Jenner, Dr. George Johnson, and others, that judicious local disinfection is very important and advantageous; various remedies may serve, but the gentle application of diluted ferric solutions has given very good results in competent hands. Dr. Nelson (New York), after ample experience of several methods of treatment, expresses the strongest conviction in favor of local applications of Monsel's solution (liq. ferri subsulphatis) diluted with glycerin and water; among forty cases thus treated he had only three deaths (*New York Medical Journal*, January, 1874). Dr. Billington, in an excellent practical essay, maintains that diphtheria is at first a local affection, and to be treated most successfully by early local disinfection; he has used lime-water, carbolic acid, etc., but gives a decided preference to the tinct. ferri perchlor., 2 parts, to 1 of glycerin; this he paints especially over the tough adherent membranes, and all adjacent parts. Three hundred cases treated upon this principle show a large percentage of recoveries, and other physicians corroborate Dr. Billington's results (*New York Medical Record*, March 25, 1876).

Bertheau describes, in a recent thesis, a severe epidemic of "diphthérite" affecting two hundred and twenty people (Indre), and in which the most useful of all the means employed was the local application of tinct. ferri perchlor. (30° Beaumé); when the membrane was unusually thick, this was painted on three or four times daily ("Du Traitement de Diphthérite," etc., Paris, 1876). Dr. Fera applies the finely powdered sulphate of iron freely to the affected part, and attributes to this the successful termination of eighty cases, while De Sabbata speaks in equally favorable terms of the use of an acid solution of the same salt (*London Medical Review*, November, 1876).

Referring now to my own experience, I find detailed notes of twenty-seven consecutive cases of diphtheria, in which the perchloride was used locally or internally; for the local application I employed an atomizer with equal parts of the solution and water, and continued its use for five

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to ten minutes every hour or two. In six cases no internal medication was ordered, but, besides using the spray, the throat was swabbed out with solution of perchloride mixed with an equal part of glycerin, two or three times in twenty-four hours. The age in these six cases varied from five to nine years, and five of them recovered; but the attack lingered longer, and its course was more unsatisfactory, and convalescence more tedious than in other instances when internal treatment was conjoined: one child, aged four years, had nasal diphtheria, and sank on the third day. In another series of six cases, including children of from two to seven years, I gave minute doses of iodide of mercury ($\frac{1}{40}$ to $\frac{1}{30}$gr.) and also liquor arsenicalis, and used freely a spray of perchloride of iron locally, and these six cases did well. The remaining fifteen, varying in age from two to ten years, were also treated by the spray, and in addition they received from 10 to 20 min. of the liquor ferri perchlor. every one or two hours, and of these cases twelve recovered. Nine of the total number had albumen in the urine on being first seen by me, and three, hæmaturia; another had severe epistaxis, and all showed much exhaustion, with more or less dyspnœa and delirium. The iron given internally seemed to exert a sedative effect on the circulation, lowering the frequency of the pulse, and rendering it more full and forcible. I have never seen hemorrhage, or albuminuria, or congestive symptoms of any kind which could fairly be traced to its action, and am indeed satisfied that its effect on the course of the disease is beneficial, though we cannot, any more than in erysipelas, consider it a "specific."

Admitting, however, that twenty-seven cases do not furnish sufficient basis for a positive conclusion, it will be desirable to review briefly the experience of previous observers. This we shall find to be strongly in favor of the iron treatment. Dr. Godfrey, of Enfield, reported three cases of "diphthérite" treated by the perchloride at the very commencement of the epidemic, and speaks of it as the best remedy (*Lancet*, ii., 1857). It was strongly recommended to the profession at about the same time by Aubrun, in France, and soon after by Dr. Heslop in this country (1858–59). The mortality before that date was most severe—thus, of twenty-six cases related by Aubrun, and treated without iron, twenty-two died. In the next series of cases, in which he used the remedy both internally and locally, out of twenty-seven three only died, and in another series of twelve cases there were no deaths at all (*Gazette des Hôpitaux*, 1859); nor does it seem that any natural lessening of virulence in the epidemic accounted for this striking and suggestive difference.

Aubrun was most particular in his method of administration, ordering one or two teaspoonfuls of a solution every five to fifteen minutes through the day and night, for the first three days of the attack, "because usually membranes would be detached, or would cease to form after that time"

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—then the medicine could be taken less frequently (*Comptes Rendus*, 1860, t. li.). Da Silva, commencing with only the local application of perchloride, soon found improved results from using it internally, and recorded many successful cases (*Gazette des Hôpitaux*, Fev., 1859). Isnard was a still more earnest advocate for this treatment. Following Aubrun in the principle that "iron strengthened the vital power" he reasoned also that it might prevent exudation just as it might hemorrhage, rendering the blood more plastic and also less liable to contamination (blood-poisoning): and, acting as an alterative on the mucous membrane of the respiratory tract it was better than alkalies, for they were too slow in action and too lowering; it should be given early and repeatedly so as to influence the blood-condition as soon as possible; in support of his reasoning he adduced thirty-nine cases, of which thirty-five got well in a natural manner, and two after tracheotomy. Dr. Heslop, after referring to the then excessive mortality of diphtheria, and the failure of all accepted modes of treatment, records several striking cases of recovery from almost hopeless conditions under the internal use of tinct. ferri perchlor: he conjoined with it local applications of dilute hydrochloric acid: at the same time that he praises the remedy, he cautions against regarding it as "a specific" (*Medical Times*, i., 1858). Mr. Pound relates equally favorable results (*British Medical Journal*, i., 1858), and Mr. Houghton (Dudley) contributes four striking cases of recovery under very unfavorable conditions (*Dublin Journal*, February, 1859). A very severe epidemic in the fen country was controlled, according to Mr. Stiles, by the same treatment (*British Medical Journal*, ii., 1858), and, of fifty-six cases, reported by Mr. Prangley, two only died after commencing the remedies: he used iodine locally and perchloride with potash chlorate internally. Mr. Salter contributed additional testimony to the same effect, and altogether the change of tone, and of the amount of mortality recorded in writings of this period, abundantly testify to the benefit derived from iron tincture, allowing even for accidental circumstances. Mr. Fisher attaches much importance to the use of a preliminary emetic or purge (*Lancet*, ii., 1862), and Dr. George Johnson, agreeing that treatment with perchloride internally is the most successful of all, conjoins with it local chlorine applications (*Lancet*, i., 1875). Sir W. Jenner, careful to place mere medical treatment in a subordinate position, states that in his experience benefit has accrued from the perchloride, as from other medicines, only in certain cases suited for it ("Clinical Lectures"), while Dr. Wade expresses some distrust of the remedy, fearing it may increase the renal congestion, for he has found, in fatal cases, more pronounced alteration in the kidneys of patients treated by iron than in others (*Lancet*, ii., 1862): he would prefer iodide and chlorate of potash. Certainly there are arguments in favor of Dr. Wade's view, but it is not supported by my own experience, and I think it will be conceded,

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that the illustrations and authorities already given, furnish ample evidence of the value of perchloride of iron in diphtheria. The appearance of albumen, blood, or tube-casts in the urine does not contra-indicate the use of iron in this disease, but, on the contrary, calls for its administration; and when blood or tube-casts are present the iron should be given in conjunction with nitric or hydrochloric acid: under the same conditions stimulants should be judiciously regulated, but seldom withdrawn. .Ordinary diuretics are injurious, but as a rule demulcents should be freely taken. Patients should be well nourished with beef-tea, soups, eggs, milk in any form, chicken panada, etc., and ice sucked or swallowed is very agreeable and relieves the painful condition of the fauces: the skin should be kept clean and warm, and the house and room well ventilated; aperients, as a rule, weaken the patient and cause an extension of the exudation in the throat; all these and other matters as they arise should be carefully attended to during the administration of any iron preparation in diphtheria.

Scarlatina—Scarlatinal Angina— Variola.—In many of these cases I have used the perchloride internally, and applied it to the throat mixed with equal parts of glycerin and water, or through an atomizer, with satisfactory results, but I recommend it most in cases which assume a malignant or putrid form; benefit is often obtained by painting the swollen cervical glands with the liquor ferri.

I have treated many cases of articular inflammation occurring during scarlatina, and closely resembling articular rheumatism, showing high temperature and great prostration, with 5 to 10-min. doses of tincture of perchloride three or four times daily, with excellent results, the joints being also painted with the liq. ferri perchlor. Meade writes to recommend the same medicine in frequent doses of 10 to 15 min. (*Medical Times*, i., 1858); and Arlidge believes it to be not only valuable as a remedy during the attack, but as a preventive of dropsy (*British Medical Journal*, ii., 1871). Fears have been expressed—as in the case of diphtheria—of its increasing renal congestion, but I have never seen injurious effects which could reasonably be traced to it, and Dr. Crighton makes the same observation (*British Medical Journal*, i., 1869). He considers that any risk of this kind may be obviated or lessened by combining liquor ammoniæ acetatis with the iron compound, thus assisting the action of the skin, and I believe the combination to be very serviceable in febrile and inflammatory cases.

The perchloride has sometimes been used with very good effect to relieve the throat-condition in variola (*Medical Record*, January, 1873), and the course of the malady itself seems to have been favorably modified; half-drachm doses of the tincture were given every four hours in a severe case occurring in the seventh month of pregnancy, and the patient did well (Ranking, ii., 1866).

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Rheumatism, Acute and Subacute.—To ascertain the value (or the reverse) of iron in acute rheumatism, I must refer rather to the experience of others than to my own. Pétrequin seems to have been the first to use it, and he reported marked advantage from doses of 40 to 80 min. given in the course of twenty-four hours; he prescribed it with lemonade, and he made trial also of the sulphate and the citrates ("Traité Pratique des Eaux Minérales," Thèse, Paris, 1855, p. 533). Dr. Russell Reynolds —led to use the remedy by consideration of its value in erysipelas— brought before the profession a series of eight cases in which the average duration of high temperature was shortened (to five and a half days as against fifteen), and in several of which pain was quickly relieved and no discomfort produced; but, on the other hand, one patient died comatose, after delirium, and another of pneumonia and pericarditis, while a feeble or intermittent pulse of 56 to 60 caused anxiety in two of the others; it is to be noted that most of these patients had some cardiac inflammation before coming under treatment, yet the results can scarcely be considered favorable (*British Medical Journal*, ii., 1869). In another series of cases, however, Dr. Reynolds was able to record greater success; thus, out of a total of sixty-five, 44 per cent. of first attacks were convalescent in the course of a week, and most of those suffering from second, third, or fourth attacks, in the second week; one-half of the whole number were severe cases, yet the temperature became normal within fifteen days; hyperpyrexia occurred in three, and proved fatal in two, instances (*British Medical Journal*, ii., 1872).

If we examine other observations that have been published on this subject, we find satisfactory results obtained by Mr. Bott (*British Medical Journal*, i., 1870), and the record of six cases successfully treated with perchloride by Dr. Dyce (*British Medical Journal*, i., 1876); and Dr. Rose finds the remedy "prophylactic of rheumatism" (*Lancet*, ii., 1871), but, on the other hand, of three cases treated by Dr. Buck, one had urgent dyspnœa, and one unusual cardiac pain (*British Medical Journal*, i., 1870), and of three cases recorded by Mr. Greene, one died with cardiac lesions, and one had tetanic spasms, so that it seems desirable to ask (with Dr. Trestrail) whether the perchloride given in acute rheumatism may not increase the disordered blood-condition, and the tendency to embolism, and to embarrassed pulmonary circulation: at least, we must say that there is at present much more doubt as to the suitability of this remedy in acute rheumatism than in erysipelas or diphtheria, and it has not commanded the same amount of professional confidence; and yet when the urine is alkaline (as in several of Dr. Reynolds' cases), and the patient is very anæmic and feeble, tincture of steel seems quite appropriate; also rheumatic pain is often relieved by it, and it has decided value in the anæmic condition following acute attacks, and in subacute and chronic varieties of rheumatism. The late esteemed Dr. Anstie

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drew attention to its power of cutting short subacute cases as observed among the out-patients at the Westminster Hospital; in such as were really rheumatic (and not gouty) in character, with sallow patchy face, deep furring of tongue, oily moisture of skin, obscure aching of limbs, slight rise of temperature, and trouble of respiration, he found that 30 to 40-min. doses, given three to six times in the twenty-four hours, often arrested the progress and relieved the symptoms in a few days; this occurred in seventeen cases out of twenty-nine (*Practitioner*, September, 1871).

Chronic Rheumatism.—Ferrum is useful in primary chronic rheumatism, also in cases when the patient is much reduced in strength and flesh after an acute attack; it should be continued for some time, for its favorable effects are but slowly produced.

Rheumatoid Arthritis.—Dr. Garrod recommends iodide of iron "in some cases of rheumatoid arthritis, especially when the joint-pains are increased by the heat of the bed." I have tried it, but have not myself seen good results from it.

Anæmia.—The various preparations of iron form our most dependable remedies in ordinary and simple cases of anæmia and chlorosis, and indeed their good effects are usually so evident that iron was, at one time, considered a panacea for all forms of these affections, but, in reality, if prescribed injudiciously, it may not only fail to cure, but may produce ill-results, and observation of such instances has led some observers to depreciate a remedy which had been considered so universally curative. Thus, Trasbot has recently denied to it any reconstituent or hæmatinic power, while Dujardin Beaumetz holds the employment of iron in anæmia "une grande illusion thérapeutique" (*Journal de Thérapeutique*, 1876). The former observer states that in experiments on dogs he obtained better hæmatinic results from lime phosphate, coffee, and wine, than he did from iron, which proved simply exciting; and Dujardin Beaumetz relies upon an argument of C. Bernard's, that even if the normal amount of iron in the blood of chlorotics be diminished, it is only by a very small amount (10 or 20 centigrammes) more than which is introduced daily in the food: but the true answer to such observations is, that all theory, and even all physiological experiment, must stand or fall by the clinical results obtained on man (Mialhe and others in *Gazette Hebdom., Mars*, 1876), and in the majority of cases these are satisfactory. The objections of Trousseau were limited to the use of iron in "false chlorosis"—that is to say, in cases when the suppression of the menses, pallor, etc., were really connected with incipient phthisis, which malady he found to be accelerated by ferruginous medicines ("Traité," vol. i.). His observations have been corroborated by Millet (*Bulletin*, 1862), but the cases quoted by the latter author illustrate mainly the injudicious domestic use of certain preparations without due examination of the patient, and his remarks apply only to the abuse, not to the medical and proper prescription of the remedy.

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By the terms "anæmia" or "aglobulia," we understand a condition in which the red blood-corpuscles are fewer than in normal health; instead of being in the proportion of 130 parts per 1,000 of the blood, they may be at 80 or 60, or even less, and this may arise from direct loss of corpuscles (hemorrhage), or from insufficient formation of new ones on account of disease, or bad air, or unsuitable food, and under such conditions the corpuscles that are formed are small and misshapen. The most marked symptom of anæmia is pallor, which affects the mucous membranes as well as the skin, and may be noted in the conjunctivæ, the gums, and the lips; other symptoms are difficulty of breathing, especially on exertion, lassitude, mental and bodily, malaise, restlessness, dyspepsia, constipation, headache, neuralgia, and palpitation: the pupils are commonly dilated. Some varieties of anæmia benefit by iron more than others, and it is not easy to lay down definite rules concerning them. If there be much dyspepsia this should first be treated by other appropriate means; but on the other hand, the simple atonic dyspepsia of anæmic persons is very amenable to iron. Congestive headache is a contra-indication, but the pulsating acute headache which follows profuse hemorrhage really requires iron medication; important points for securing its good effects are, to obviate constipation by aperients if necessary, and to secure sufficient oxygen for the proper assimilation of the remedy, and I think that many failures in the treatment of anæmia are traceable to want of management on these points.

Direct anæmia dependent upon excessive hemorrhage; or the indirect anæmia which follows loss of animal fluids generally (such as in obstinate leucorrhœa, empyema, and purulent formations, seminal losses, profuse perspiration, diarrhœa, prolonged lactation, or too frequent pregnancies); also the anæmia produced by acute disease, such as rheumatism, and that connected with inanition when the albuminous constituents of blood are really most deficient; all these forms, though complicated with extreme debility and general hydræmia, may gradually improve with good food, rest, and pure air (especially if the cause be removed), but iron, given in suitable doses and not so as to disorder the stomach, will greatly assist and hasten recovery.

In other cases, the best dietetic measures alone are insufficient, and iron is indispensable for cure: in the congenital anæmia of children born after profuse uterine hemorrhage, or whose parents were affected with anæmia, tuberculosis, constitutional syphilis, or other exhausting diseases, iron is of special value; also in strumous and rachitic cases (when the iodide or the phosphate is the most suitable form), but it requires to be continued for a long time. I have always found, in the treatment of simple anæmia, that when, under the judicious use of iron, etc., the blood assumes a healthy aspect, and the formidable symptoms disappear, if the iron medication is not persevered with for a considerable time longer,

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the malady returns in an aggravated degree. Anæmia arising from severe and continuous mental strain is best treated by the phosphate conjoined with cod-liver oil—many cases have come under my observation when this treatment proved highly beneficial. In the anæmia due to mal-hygiene, to sedentary pursuits, prolonged residence in a town atmosphere, or continued exposure to carbonic acid, iron compounds are also markedly useful. In all these forms their advantage has been often verified by the enumeration of the blood-corpuscles, and estimation of the amount of coloring matter.

Idiopathic or "Pernicious" Anæmia is an extremely interesting but obscure form of disease, connected mainly with the glandular system; it is insidious and fatal, and iron, at least in the forms usually employed, has seemed to possess little or no remedial power against it: arsenic, and perhaps phosphorus, have succeeded better (*v.* p. 50). Quite recently, however, benefit has been reported even in this malady from the hypodermic use of iron, and Da Costa has further exemplified the value of this resource by the cure of an obstinate case of chlorosis with hypodermic injections of "dialysed iron" in 15-min. doses (*British Medical Journal*, i., 1878). I should consider this an additional proof that in many cases where iron is said to have failed, it is because of its not being given in a form that can be assimilated.

In ordinary goître, iron alone is inefficient, and in *exophthalmic goître*, although anæmia is commonly a marked symptom, I have not seen much advantage from it. In the anæmia of incipient phthisis it must be given with caution (*v.* p. 173); and in that connected with diabetes and malignant or malarious disease, its effects, though often good, are rather uncertain.

The success of iron in anæmia will clearly vary with the different causes, forms, and degrees of the malady, and an accurate knowledge of them is a great help toward cure of the disease, and confidence in the power of the drug. Cases coming under treatment at an early stage usually admit of a favorable prognosis, but when the anæmia is congenital, or occurs at the climacteric period, recovery is more uncertain, and the anæmia of old people (unless when directly consequent on an acute illness) is the least tractable of all; intercurrent disease, especially if of febrile or inflammatory character, renders the prognosis as to the anæmic condition, very doubtful.

It is worth while, even at the present time, to refer briefly to two of the earliest facts which fixed the value of iron in suitable cases of anæmia. An endemic malady, apparently unknown at the time (1804), attacked the workers in the mines of Anzim (coal); it was probably anæmia from carbonic acid poisoning, for they became pale, feeble, short of breath, and died of asthenia, or chest disease. Treatment by quinine, opium, good food, etc., failed to relieve, and four cases were sent to a hospital

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in Paris for the opinion of the physicians: of the four men, one died shortly, and at the section, Hallé, noticing the exsanguine appearance of the body, thought of iron, and prescribed it for the others, who got well, and returning home cured their companions with the same remedy (Quevenne: "Mémoire," etc.). Something similar occurred at the mines of Schemnitz (metal mines), where the workers at one time died rapidly with "anæmia, asthma, phthisis, and dropsy," when the epidemic was stayed with iron medicines by Hoffinger (Ozaman: "Histoire des Epidemies").

Chlorosis.—The relationship of chlorosis to anæmia is not exactly clear, but it has this in common with it—that the number of red corpuscles is diminished, and that those which are visible are mostly small, some are shrivelled and irregular, and all are pale-colored; the serum is in excess: in causation, also, it is allied, as it occurs often in young girls obliged to live in close, ill-ventilated rooms or workshops, and it has also, sometimes, seemed directly due to the hemorrhage of the first menstruation (Wade).

As an entirely primary disease it seldom occurs in any but unmarried women, and chiefly from thirteen to twenty-four years of age; if it occur later in life, it is usually traced to frequent confinements coming rapidly one after another, and especially if the women nurse their children. It is connected with deranged menstruation and certain sexual causes which we are at present unable to distinguish accurately: it occurs either before the menses have appeared, or after symptoms of disordered menstruation have continued for some months; dysmenorrhœa and leucorrhœa are frequent precursors of it. It is often hereditary; the children of tuberculous parents and delicate women with irritable nervous systems are the most susceptible to it: sometimes, in exceptional cases, menstruation is too frequent and profuse. The patient is subject to most of the symptoms already described under anæmia, especially dyspnœa, palpitation, headache, giddiness, and dyspepsia: the face is œdematous and pallid, with a greenish hue; the condition lasts longer than ordinary anæmia, and relapses are still more liable to occur.

The cure of this affection is often readily accomplished with suitable diet, pure air, exercise, healthy mental occupation, and a steady course of iron, which latter is almost a specific in all simple cases. It was formerly thought that the metal acted by supplying some deficiency in the blood, or at least by directly increasing the number of corpuscles. Béhier considered that it was always indicated when he found, on microscopical examination, that the red globules were reduced to a proportion of 80 per 1,000, and to some extent this is a guide. General improvement will usually occur *pari passu* with an increase in their number toward the normal amount, but it must be understood that the action of iron is not simply a mechanical or chemical one. Claude Bernard has shown by an-

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alysis that the metal, as such, is not always deficient in amount in chlorotic blood, and Hayem has shown that the number of corpuscles is not always diminished before, nor increased after the use of iron; on the other hand, the latter observer has clearly shown that the size, and color, and "vital character" of the corpuscles are remarkably improved by it. It acts, therefore, as a stimulus in some manner peculiar to itself, or, as others have expressed it, it has a "dynamic or vital influence" which chemistry alone will not explain (Trousseau, etc.; *see* also Physiological Action).

With regard to the preparation that is most suitable, we may refer to the observations of M. Coste. He made trial of different forms in 118 cases, fifty-five being of chlorosis, and he concluded that the choice of any particular one was not in itself important, if irritation of the stomach did not result—every preparation that did not irritate produced the good effects of iron; the reduced metal, taken at meal times in small quantities, proved on the whole the most satisfactory form, and the experiments of Quevenne, and the observations of Chomel, Trousseau, and others, are to the same effect. Sydenham obtained remarkable success with iron filings and iron wine, and, as a rule, we may say that the simpler the form used the better, and chemical theories as to solubility, etc., do not guide as to the therapeutical result. The ferrum redactum, the oxides and proto-salts, especially the carbonate, are certainly to be preferred in the earlier stages of chlorosis, unless the occurrence of mucous or other discharges indicate a necessity for astringents: sometimes the metal itself causes unpleasant eructation, and the oxides are liable to adulteration, and hence the recently precipitated carbonate, which is not astringent or irritant, is preferred by many, and in the form of mist. ferri comp., or Griffith's mixture, has had great repute in the treatment of anæmic amenorrhœa. The "Pilules de Blaud" contain carbonate of potash and sulphate of iron, and have for many years retained a high reputation in the treatment of chlorosis, especially on the Continent (Niemeyer): his original memoir, recording thirty successful cases, is republished by Bayle, and will repay perusal (*Biblio. de Thérapeutique Journal*, iv., 1837). I have but little personal experience of the value of the hydrated oxide, or "dialysed iron," which seems pure and non-irritant; the doubts expressed about it seem to be mainly theoretical (Bouchardat: *Bulletin*, January, 1878; *Medical Times*, 1878; *British Medical Journal*, ii., 1878). I have had excellent results from a protochloride, and sometimes the citrate with ammonia will be borne better than any other. Dometz specially recommends an albuminate (*see* Preparations), and in the anæmia so common in Japan, and traceable to intestinal catarrh, found it better borne than any other form. I have seldom seen the astringent forms, when given in a right dose, and at a proper time, produce any injurious effect on a weak or irritable stomach; indeed, in many such cases I have found

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them particularly suitable, and we need not be deterred from their use by fear of irritating effects: astringent preparations, such as the perchloride and sulphate, should be used in cases of "menorrhagic chlorosis," for it is found practically better to treat the anæmia in such cases than to omit iron for fear of increasing hemorrhage (Trousseau). This applies especially to cases where the discharge is profuse and frequent, but pale and imperfectly coagulating; but, even when it is florid in character, iron may be ordered with advantage, if due attention be first given to such symptoms as hepatic congestion and constipation. Astringent preparations are also useful if there be a tendency to palpitation, general relaxation, or undue discharges of any kind, and also when impairment of nerve-power is a marked symptom. Aloes is often added to reduced iron or iron carbonate, in phlegmatic subjects, and sulphate of magnesia to medicines containing iron sulphate, especially if the patient be *plethoric;* sometimes small doses of belladonna will regulate the bowels, preventing constipation better than either of these aperients. In all cases, success will depend not upon giving a large quantity of the medicine, but upon *securing its due assimilation;* for this purpose, air and exercise are important, and fatty food certainly aids the digestion of iron (Nasse: *British Medical Journal*, ii., 1877). Jeannel found that an oleo-stearate of iron, prepared with the sulphate and white soap, was very well borne: nitro-hydrochloric acid baths also favor the absorption of iron (Chambers: *Medical Times*, i., 1862).

It is important in all cases to continue the remedy sufficiently long, and not to omit it on the first symptoms of improvement; permanent benefit can seldom be expected under five or six months.

In cases where iron had not been given properly, and when it afterward failed to produce due effect, I have found great advantage from *arsenic* alone, or in conjunction with iron. Manganese has also been recommended (Pétrequin).

Anœmia of Pregnancy.—We consider iron not a direct, but an indirect emmenagogue, by virtue of its improving the blood-condition; but since the continued use of the mineral can cause congestion of the pelvic, as well as of other organs, it becomes an important question as to whether its use is admissible or is dangerous during pregnancy. Certainly the perchloride has been in frequent popular use as an abortifacient, but the evidence of its power for this purpose is not cogent (*v.* p. 147). Its use has often furnished occasion for prosecutions, but few cases of its really causing abortion are recognized, and, in many of these, as well as when the sulphate has been used, the effect seems to have followed from violent irritation of the intestinal canal. It is true that cases in which abortion is deliberately produced would not, as a rule, find their way into the public press; but, allowing for this, I find a general impression gaining ground that iron may be taken during pregnancy without injurious effects.

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Ramsbotham and Barnes recommend it, the latter stating that he has never seen harm from it (*Lancet*, i., 1874, p. 768). It was stated during a recent trial that 10-gr. doses of ammonio-citrate of iron were dangerous to a pregnant woman, but Dr. Woodman contradicted this from his own experience, and Dr. Graily Hewitt said that he and others constantly prescribed it during pregnancy (*British Medical Journal*, i., 1870). Dr. Bassett brought before the Obstetrical Society many cases illustrating the value of the citrate and tartrate of iron in averting miscarriage and serious hemorrhage in delicate women, and there seems to have been no difference of opinion upon the subject (*Lancet*, i., 1874, p. 768): he considers that the addition of an alkali to the iron medicine renders it better borne, and points out that aperients should be given occasionally during the course. I can corroborate the experience of Dr. Bassett, and I think that the neutral preparations of iron are the most suitable during pregnancy, though some observers speak well even of the perchloride (Day: *British Medical Journal*, i., 1870). Trousseau remarks that iron has no direct emmenagogue power, and Hirtz has never seen any objection to using iron in the anæmia of pregnancy, though he has not found it very useful ("Dict. de Méd."); altogether we must conclude that the older fears of injury from its moderate medicinal use were unfounded.

Phthisis.—A great deal of fear has been expressed about the use of iron in this malady, and it has been said by eminent observers to hasten and aggravate its course, especially when given in full doses and in the early stages (Trousseau, Millet: *Bulletin de Thérapeutique*, 1862, etc.). If there be acute pyrexia and evidence of pulmonary congestion, leading to florid hæmoptysis, then I think that iron is better avoided, because it can increase blood-pressure and congestion, and stimulates blood-formation, and in any case it should be given with much caution during the early stages of the malady, and special attention should be directed to supplying at the same time any deficiency of fatty food, and to securing a due supply of oxygen (Dobell: *British Medical Journal*, i., 1867). Iodide of iron is one of the best preparations to use, especially in "scrofulous phthisis," and it should be combined, if possible, with cod-liver or other oils. In *later* stages of phthisis, all are agreed as to the value of iron in relieving many of the most distressing symptoms and much assisting any measure of recovery that can be obtained: the astringent preparations control purulent formations and discharges of various kinds, such as expectoration and passive hæmoptysis, diarrhœa, and profuse perspiration, and they often improve the strength and the appetite. Bonorden used the sulphate in a number of cases, giving from 2 to 4 gr. every two hours for several days at a time: the dose seems large, but he obtained very good results (*Schmidt's Jahrb.*, May, 1852). Dr. Thompson employed chiefly the perchloride at the Brompton Consumption Hospital, and calculated the effects of iron medication in more than 1,500

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cases,—54.6 per cent. were found "improved," 23 per cent. much improved, and only 21 per cent. not improved. He does not give the details of any cases, nor does he mention the stages of the disease when iron was used, but states generally that the patients grew stronger, and were able to eat better, and suffered less from flatulence, diarrhœa, night-sweats, and hæmoptysis: he considers that iron is clearly required in the treatment of phthisis, because "it improves the condition of the blood," and he advocates its continued but moderate use "as a food" (*Practitioner*, vol. i.). Others have written special treatises in favor of this medication. Dr. Cotton obtained favorable results from the iodide and ammonio-citrate (*Medical Times*, i., 1860), and Sir Thomas Watson recommends iron in non-inflammatory forms of phthisis, "and finds the mist. ferri comp. very useful when it is well borne:" if sweating be profuse, he uses the perchloride. Dr. Cameron recommends the basic iodate of iron as better than the iodide: it contains 51 per cent. iodine and 11 per cent. iron (*Dublin Quarterly*, May, 1869).

Chronic Bronchitis—Emphysema.—In chronic bronchitis, with profuse expectoration, I have found iron compounds, especially the perchloride and the phosphate, often useful; besides improving the general health, they lessen the amount of secretion and modify its character. In emphysema the perchloride is often valuable for its tonic power and its action on the capillaries, as well as for improving the impaired blood-condition.

Cardiac Disease.—Cardiac pain and dyspnœa may often be relieved by iron preparations, which act probably in an indirect manner—*i.e.*, by improving the blood in the first instance, hence their advantage is seen most in cases of anæmia: in such conditions, occurring after acute rheumatism, even the physical signs—murmurs, etc.—may improve under a course of iron (Jones: *Medical Times*, 1861). Increased frequency of pulse is not, in itself, a contra-indication, but only when increase of tension is also detected. In mitral disease with dropsy, the acetate or perchloride is especially useful if combined with diuretics: in fatty degeneration of the heart, in any form of chronic valvular disease, and in dilatation, iron is often serviceable, especially when combined with digitalis.

Serous Effusions—Dropsy.—Iron acts powerfully in dropsy resulting from a state of anæmia or hydræmia of the system, and good effects may be obtained from 3 to 5 gr. of ferrum redactum taken at meal times, or 15 to 30 min. of tincture of perchloride about half an hour after meals. Dropsy dependent upon mitral disease is best treated by iron and digitalis (in addition to purgatives), and dropsy connected with albuminuria is very amenable to the same combination: it should not be used during acute renal congestion (cf. Rotta: "Fer en Hydropisie," *Annuaire de Thérapeutique*, 1857). Husemann praises it in "cachectic dropsy," and

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in that form which is connected with chronic nephritis and amyloid degeneration of the kidney. Dr. Anstie has written strongly in favor of the tincture of iron in chronic pleuritic effusion, and my own experience quite corroborates his observations.

Albuminuria.—The astringent preparations of iron are often exceedingly useful in controlling the loss of albumen by the urine: we must remember, however, that it is also possible to do harm by these remedies in renal diseases, and I have seen congestion increased by recourse to them during the acute stage. The best effect is certainly obtained at the decline of this stage, when the urine is free from blood or inflammatory casts, when pain in the back, and in the head, and the general febrile conditions are relieved, but the patient is pallid, weak, and suffering from more or less anæmia and dropsy; then the value of such preparations as the perchloride or acetate is often very marked, both as regards the general health and the discharge of albumen. Dr. Hassall, indeed, attributes these good effects more to a reconstituent action on the blood, "than to any direct astringent power, because he could not detect either the metal, or the acid combined with it (hydrochloric), in his analysis of the urine" (*Lancet*, ii., 1864). Dr. Parkes was one of the first to show, by quantitative analysis, the gradual lessening and final cure of the discharge of albumen under the influence of perchloride; this was in a subacute case, when the early inflammation had subsided, and hospital nursing and the use of gallic acid had quite failed to relieve (*Medical Times*, ii., 1854). In all cases of this kind it is desirable to feel one's way with iron preparations, to begin at first with a small dose; and the recommendation of my late friend Dr. Basham, to combine with it the acetate of ammonia, is a very good one. The addition of ergot will increase the astringent effect (*v. Gazette Méd. de Lyon*, October, 1862), and in albuminuria following scarlatina, especially when dropsy is present, tincture or infusion of digitalis, alternately with tincture of perchloride of iron, is a very valuable prescription: it increases the flow of urine, at the same time that by its action on the blood and the capillaries it restrains the transudation of albumen: Dr. Goodfellow and Dr. Cheadle have reported favorable results with it (*Medical Times*, 1871; Ranking, i., 1873).

In chronic forms of albuminuria iron will require consideration: it is often extremely useful, improving the blood-condition more than any other remedy, and Dr. Lionel Beale testifies to its good effects even in chronic structural change and fatty degeneration (*Medical Times*, i., 1865, p. 29), but the cases in which it does harm are those with granular kidney, when the heart is large, the pulse hard and of high tension, and when there is much tendency to headache (Dickinson: *Lancet*, i., 1876). Hirtz says that he has seen it hasten a fatal termination by uræmia, lessening the amount of urine, and increasing that of urea ("Nouv. Dict.," Art. Fer), so that its effects should always be carefully watched: a very

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important point when ordering iron in any case of albuminuria is to obviate constipation.

Chyluria.—The perchloride of iron has sometimes proved very useful in cases of this kind, even when they have lasted for several years (*Lancet*, ii., 1862).

Diabetes.—Carbonated iron waters are much esteemed as adjuvants in the management of diabetes; and Dr. Mackey informs me that the bromide of iron, or rather a combination of bromide of potassium and citrate of iron, has given better results than any other medicine in his experience. Of course, the diet and hygiene must be regulated, and when we can more accurately distinguish the varieties of the malady we may find that certain medicines are more appropriate to some forms than to others, but meanwhile I believe the bromide of iron is available in any ordinary chronic case: I have frequently seen the general health improve, and the amount of sugar grow less under its use.

Dyspepsia.—Although iron is contra-indicated in cases of acute and irritative dyspepsia and mal-assimilation, yet certain forms of "atonic dyspepsia" which are connected with debility and impaired blood-condition are well treated by it. There are the general symptoms of anæmia, and also a sense of weight and heaviness after food, and impaired appetite, rather than of acute pain, and the preparations usually most suitable are such as the citrate or ammonio-citrate combined with soda and calumba, or reduced iron with nux vomica: the headache which often accompanies this condition is also relieved by these medicines: when there is much general relaxation, or gastric catarrh of chronic character, the perchloride, preferably with quassia, is valuable. In the dyspepsia of chlorosis, iron will often not agree if the tongue be furred, or the urine loaded; but if these conditions are present only in a minor degree, then the citrate may be used in effervescence with soda (Budd: "On Dyspepsia"). Dr. Milner Fothergill, in an article "When not to give Iron," insists on the importance of clean tongue and freedom from "biliousness;" and he quotes Sir J. Fayrer to the same effect (*Practitioner*, 1877); he remarks also that toleration of it diminishes with age.

Diarrhœa.—In simple cases, occurring in weakly children, and continuing after preventable causes have been removed, the vinum ferri is a mild but very useful astringent tonic, which is often sufficient both to stay the discharge, and to prevent its recurrence. In more serious cases of chronic mucous diarrhœa with slimy, bloody, offensive stools, and tenesmus, whether met with in adults or in children, the best preparation is the liquor ferri pernitratis, in doses of from 1 to 5 drops, as originally recommended by Neligan, and I have seen also much benefit from its use in the colliquative diarrhœa of phthisis. Dr. Graves specially advised it in the "nervous diarrhœa" which is liable to occur from emotional causes, and is more frequent in women: in cases with nausea and impaired ap-

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petite, calumba may be well added to the iron (*British Medical Journal*, ii., 1870; Dr. Cooke).

Dysentery.—I cannot recommend iron preparations during the acute stage of dysentery, for I believe there are much better remedies, but some practitioners have found iron valuable. Bandon reports twelve cases suffering with tormina and very frequent sanguineous stools, which were treated by 12 to 30 min. doses of steel tincture internally, at the same time that about 12 min. with water (and sometimes laudanum) were injected; these cases were much relieved or cured within a week (*Bulletin de Thérapeutique*, folio 71). Blanvillon corroborated these results (*Gazette des Hôpitaux*, No. 130), and the same medication was largely used during the last German war (*Lancet*, ii., 1870): as a general rule, it is better restricted to chronic stages of dysentery, and for the anæmia and debility attendant upon this condition it is of great value.

Cholera.—Iron is one of the numberless remedies recommended for cholera, but I have very little personal experience of its use: it would, of course, not be depended upon alone, and Robiquet has reported a number of successful cases treated by the citrate and by reduced iron with quinine; frictions, and warmth, and nutriment being also conjoined (*Journal de Médecine*, October, 1873; *Practitioner*, vol. xi., p. 452).

Nervous Disorders—Hypochondriasis, etc.—The nervous system naturally suffers when it does not receive a due supply of healthy blood: depression and a sense of oppression will be felt, and hysterical and hypochondriacal symptoms will be more or less pronounced: in such cases, iron is often a valuable adjunct to other treatment, and is especially suitable when combined with bromides. In the nerve-symptoms which commonly occur in women at the climacteric period, including restlessness, anxiety, fluttering and sinking at the epigastrium, giddiness, clavus, and sometimes menorrhagia, the perchloride, with or without bromide, relieves much.

Dipsomania.—Morbid craving for drink, and alcoholic insomnia, have been controlled by drachm doses of tincture of iron when many other remedies have failed (*Medical Times*, i., 1875). The sulphate has also given relief in such cases, especially when combined with aromatics.

Neuralgia.—Before the introduction of many modern remedies for neuralgia, large doses of the carbonate or oxide of iron were much relied upon, and when there is a chlorotic anæmic condition of system they are of service. I should not myself consider iron a remedy for "idiopathic neuralgia," but some observers have attributed to it almost a specific power, especially in neuralgiæ of the fifth nerve: thus, Mr. Hutchinson recommends it in "prosopalgia," and, according to Schobelt, the phosphate of iron acts well in neuralgia of the teeth: the citrate of iron and quinine is a very good form when the remedy has to be long continued.

When *neuralgia of the stomach* occurs in anæmic or chlorotic patients,

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who complain of cramping pain and distension, accompanied with nausea and vomiting of mucus and water, principally before breakfast, and of frequent acid and insipid eructations after meals—iron is useful, especially when the neuralgia depends on loss of blood or on protracted diarrhœa; I have notes of many such cases cured by it.

Chorea.—When this disorder is dependent upon anæmia, iron is clearly indicated, and may prove of great service, as it did in the hands of Elliotson, who used large doses of oxide (*Medical Times*, i., 1869, p. 136). Sir T. Watson recommends the carbonate. Many cases occur about the time of commencing puberty, and others evince obscure rheumatic symptoms: and in these also iron is useful, but it often acts better when taken in conjunction with arsenic.

Epilepsy.—Ferruginous medicines were at one time esteemed in the treatment of epilepsy or of attacks resembling it, but as diagnosis became more exact, and as more reliable remedies were discovered, iron passed out of use. Brown-Séquard taught that although it might improve the blood-condition, it tended to aggravate the malady itself; and H. Jackson, after much observation, expressed the same opinion. Dr. Gowers, writing more recently, acknowledges that it is sometimes the case, but, on the other hand, he has found that iron has a true place in the therapeusis of epilepsy: he has observed benefit from it in cases that are on the borderland between epilepsy and hysteria, and in others when the attacks were limited to the night-time, and in many of these cases the improvement was fairly permanent: he suggests, and I should think very plausibly, that it acts, like other metals (as silver or zinc seems to do in such cases), as a nerve-tonic, rather than simply by hæmatinic properties (*Practitioner*, October, 1877). Fabre has published a thesis showing the value of the medicine ("Fer contre l'Epilepsie," Paris, 1853). On the whole, we may conclude that iron has been unduly discredited in epileptic or epileptiform conditions. I think that when it arises from onanism, or when a patient is anæmic, it should be used, but generally in combination with bromides.

Constitutional Syphilis.—This malady, like all others in which a poisonous material circulates in the blood, much impairs the condition of that fluid, rendering the corpuscles fewer, smaller, and paler; and, in such cases, iron becomes very serviceable, though it will not take the place of more special remedies for the principal disease. Ricord recommended the potassio-tartrate even in primary syphilis, and especially for phagedænic ulceration in debilitated subjects: the theory sustained in opposition to him by certain French writers, that iron aids the development of the malady, is not tenable. The iodide of iron I have found very useful in the later stages of syphilis in cachectic subjects.

Struma—Rachitis.—In the different forms of disease included under these headings, and characterized by enlarged or suppurating glands,

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irritable mucous membranes, caries, and swelling of knee and elbow joints, emaciation, etc., iron, although much lauded by Hufeland, is not so serviceable when given alone as are certain alteratives—iodine, lime, etc.—but when combined with such remedies it is of great value for the cachexia, anæmia, and torpor of the blood-forming glands, which are usual accompaniments; I have, indeed, found the iodide of iron to be an excellent remedy for most affections of a scrofulous type. The perchloride, as already mentioned, is a good external application for discharging glands. The vinum ferri, or an alkaline citrate with aromatics, is very useful in the *mucous diarrhœa* of rachitic children.

Worms.—The astringent tonic effect of perchloride on the gastro-intestinal mucous membrane, renders it a good adjunct to purgative treatment for these parasites, and a useful prophylactic. When diluted, it may be injected into the rectum for destroying ascarides: I generally use about 1 dr. of the liquor in 4 oz. of infusion of quassia: a stronger solution is liable to cause unnecessary pain.

Preparations and Dose.—Iron preparations, especially the liquid astringent forms, discolor the teeth and stain the tongue black—they should be taken through a glass tube: glycerin lessens the rough astringent taste, and a gargle of milk will relieve it (Guibout). A lotion of quadroxalate of potash (½ dr. in ½ pint of rose-water) will remove the black staining.

Mistura ferri aromatica (made with iron wire, cinchona, calumba, and aromatics): dose, 1 to 2 fl.oz. *Vinum ferri* (made with iron wire and sherry): dose, 1 to 2 fl.dr. and upward. *Ferrum redactum:* dose, 2 to 6 gr. for adults; ¼ to 1 gr. for children. *Trochisci ferri redacti:* each lozenge contains a grain of reduced iron. Reduced iron may be taken with advantage during a meal, the powder being mixed up with the food.

Ferri oxidum magneticum: dose, 3 to 5 gr. or more. *Ferri peroxidum hydratum:* dose, 10 to 60 gr. or more in treacle or honey. *Emplastrum ferri—Chalybeate plaster* (contains hydrated peroxide of iron, Burgundy pitch, and lead plaster). *Ferri peroxidum humidum:* dose, 2 to 4 dr.

Ferri carbonas saccharata: dose, 5 to 20 gr. or more. *Mistura ferri composita* (contains sulphate of iron, carbonate of potash, nutmeg, sugar, and rose-water): dose, 1 to 2 fl.oz. *Pilula ferri carbonatis* (contains saccharated carbonate of iron and confection of roses): dose, 5 to 20 gr. or more.

Ferri iodidum: dose, 1 to 5 gr. or more. *Syrupus ferri iodidi* (contains iodine 2 parts, iron 1 part, with sugar and water): dose, 20 to 60 min.: each fluid drachm of the syrup contains nearly four grains and a half of iodide of iron. *Pilula ferri iodidi:* dose, 3½ to 8 gr. or more; one grain of iodide of iron is contained in about 3½ gr. of the pill.

Ferri sulphas: dose, 3 to 5 gr.: the "Pilules de Blaud" contain carbonate of potash with sulphate of iron. *Ferri sulphas exsiccata:* dose,

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½ to 3 gr. or more (3 gr. with 2 of manna make a good pill). *Ferri sulphas granulata:* dose, 3 to 5 gr.

Ferri arsenias: dose, $\frac{1}{16}$ gradually increased to ⅛ gr. in pill. *Ferri phosphas:* dose, 5 to 10 gr. *Syrupus ferri phosphatis:* dose, 1 dr. and upward (contains soda and phosphoric acid with 1 gr. of the iron salt in each fl. dr.; is colorless when fresh).

Liquor ferri perchloridi fortior: dose, 3 to 10 min. *Liquor ferri perchloridi*[1] (contains 1 part of the last-mentioned to 3 of distilled water, sp. gr. .995): dose, 10 to 30 min. or more. *Tinctura ferri perchloridi* (contains 1 part of the stronger solution to 3 of rectified spirit, sp. gr. .995): dose, 10 to 30 min. or more. *Ferri pernitratis liquor:* dose, 30 to 60 min. *Ferri persulphatis liquor* (chiefly used in preparing other ferruginous salts).

Ferri et ammoniæ citras: dose, 5 to 10 gr. or more. *Vinum ferri citratis* (prepared with orange wine): dose, 1 to 4 dr. *Ferrum tartaratum:* dose, 5 to 20 gr. *Ferri et quiniæ citras:* dose, 5 to 20 gr. *Tinctura ferri acetatis:* dose, 5 to 30 min.

[PREPARATIONS, U. S. P.—*Ferrum redactum; Mistura ferri composita:* myrrh, sugar, each 60 gr., carbonate of potassium 25 gr., sulphate of iron 20 gr., spirit of lavender ½ fluidounce, rose-water 7½ fluidounces; dose, 1 to 2 fluidounces; *Pilula ferri carbonatis:* sulphate of iron 8 troyounces, carbonate of sodium 9 troyounces, clarified honey 3 troyounces, sugar 2 troyounces, boiling water 2 pints, syrup sufficient; dose, 2 to 10 grains; *Ferri subcarbonas; Trochisci ferri subcarbonatis* (they contain 5 gr. each of the subcarbonate); *Emplastrum ferri; Ferri chloridum; Liquor ferri chloridi; Tinctura ferri chloridi; Ferri citras; Liquor ferri citratis; Ferri et ammonii citras; Ferri et ammonii sulphas; Ferri et ammonii tartras; Ferri et potassii tartras; Ferri et quiniæ citras; Ferri et strychniæ citras;* dose, 3 to 5 gr.; *Syrupus ferri iodidi; Pilula ferri iodidi; Ferri lactas; Ferri oxalas;* dose, 2 to 3 gr.; *Liquor ferri nitratis; Ferri oxidum hydratum* (used as an antidote to arsenic); *Ferri phosphas; Ferri pyrophosphas; Ferri sulphas; Ferri sulphas exsiccata; Liquor ferri subsulphatis* (*Monsel's styptic*); *Liquor ferri tersulphatis* (used in preparations); *Pilulæ ferri compositæ:* myrrh 36 gr., carbonate of sodium, sulphate of iron, each 18 gr., syrup sufficient: make 24 pills; *Ferri sulphuretum.*]

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[1] The tincture of perchloride often becomes turbid, which is due to it not containing sufficient chlorine, part of this gas being driven off by the long process of evaporation which is required in order to drive off nitric acid; the quantity of acid ordered in B.P. is 25 per cent. over the quantity required by chemical calculation, and Schacht finds that by using less (20 per cent. less) he obtains a preparation having less hyponitrous ether, and which keeps better (Pharmaceutical Journal, September, 1872). The U.S. Pharmacopœia specially provides for the development of muriatic ether in the tincture.

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The non-officinal preparations are very numerous, and include the following:

Preparations of Tisy (French): these are all proto-salts, and are sent out in capsules—as of Fer ioduré, etc.; analysis shows the quantity contained in each capsule to be very small, and not constant (*Practitioner*, vol. vii.).

Preparations of Creuse (American): these are double salts, such as a phosphate with ammonio-citrate—non-astringent: he has also a tasteless iodide and chloride (*Pharmaceutical Journal*, May, 1873, and February, 1874).

Preparations of Robiquet (French): these are double salts, as a citro-ammoniacal phosphate; they are not definite in composition. *Preparation of Béchamp* (French): this is a peroxychloride, obtained by treating neutral perchloride with a varying quantity of peroxide; it is tasteless, not caustic or irritant, but hæmostatic (*Medical Record*, 1874, p. 795). *The preparations of Lebarqui, Bravais, Squire, Chateaud, and Manghan* are different forms of oxide—"dialysed," "soluble," colloid. *Van den Corput's preparation* is a double citrate of iron and magnesia (Belgian): that of *Saquet* is a pyrophosphate with soda, ammonia, and malt extract. *Lightfoot's solution* is said to be a magnetic phosphate.

Besides these, we have in more common use—*Bromide of iron:* dose, 1 to 5 gr. *Pyrophosphate of iron:* dose, 5 to 10 gr. *Hypophosphite of iron syrup:* dose, 1 dr. (*Pharmaceutical Journal*, v., vii.). *Parrish's syrup of phosphates* (compound), containing in each drachm 1 gr. phosphate of iron with soda and potash; *Dr. Frederick Churchill's syrup* (*v. British Medical Journal*, March, 1880); *Beef and iron wine* (Burroughs); *Monsel's solution* (liq. ferri subsulphatis); and many others.

HYDRARGYRUM—MERCURY—QUICKSILVER, Hg,=200.

Mercury is most frequently found in combination with sulphur, as native sulphide or cinnabar, in mines in Almaden, Ydria, China, Peru, Japan, and California. It is obtained from the ore by fusion with lime, which combines with the sulphur, while the mercury distils over. It occurs, also, as a natural amalgam with silver—"argental mercury"—combined with chlorine in small gray crystals, known as "horn mercury;" also more rarely as an iodide, and sometimes in a pure state—"virgin mercury."

CHARACTERS AND TESTS.—Mercury is a silvery-white metal, with bluish lustre, and is fluid at ordinary temperatures. When pure, it has neither taste nor smell; it readidly oxidizes on exposure to the air, but does not tarnish. Should tarnishing occur, it implies the presence of

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other metals, as lead, zinc, or bismuth; it is susceptible of such division, that it may be squeezed in minute globules through chamois leather. On agitation with alcohol, ether, or turpentine, or on trituration with sulphur or unctuous substances, it loses its fluid character. With other metals, and even with hydrogen, it forms soft compounds termed *amalgams*, and a mere trace of it will leave a white stain on silver or gold. It has a sp. gr. of 13.59, which is exceeded only by that of gold and platinum, is slightly volatile at ordinary temperatures, boils at 662° F., and freezes at 39° F., becoming crystalline, tough, malleable, and sonorous. Its specific heat is low, but it is a good conductor, and has a regular rate of expansion and contraction, hence it is well suited for thermometric and barometric purposes: from its power of combining readily with silver and gold, and yet afterward quickly volatilizing on being heated, it is valuable in the arts of gilding and silvering, and alloyed with tinfoil it forms the reflecting surface of mirrors.

Hydrochloric acid has no action on mercury, and hence the chlorides cannot be prepared in a direct manner. Sulphuric acid, when boiling, and nitric acid, whether cold or hot, form respectively salts of different degrees of saturation—*proto-* or *sub-salts* which are known as *mercurous*, and *per-salts*, known as *mercuric*, and which have much more active powers than the former.

The per-salts of mercury are many of them (as the perchloride and red iodide) soluble in ether when the sub-salts are not, so that by this agent they may be separated from each other.

If any salt of mercury be heated in a test tube with sodic carbonate, the pure metal will sublime, and it may be obtained from its various combinations by distillation. With sulphuretted hydrogen in excess, mercurial compounds give a black precipitate of sulphide; but the best general test is the deposition of metallic mercury upon bright copper. It may be applied by heating any mercurial salt with a strip of copper and a few drops of hydrochloric acid, and, if the copper be afterward heated, small globules of quicksilver may be obtained as a sublimate.

Compounds of Mercury.

HYDRARGYRI SUBCHLORIDUM—CALOMELAS—MERCURIUS DULCIS—SUBCHLORIDE OF MERCURY, OR MERCUROUS CHLORIDE—CALOMEL, Hg_2Cl_2, =471.

Preparation.—(1) Ten parts of sulphate of mercury are triturated with seven of metallic mercury and a little water, so that a subsulphate is formed—thus

$$HgSO_4 + Hg = Hg_2SO_4.$$

(2) Chloride of sodium is then added with trituration, the mixture is

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heated, and the subchloride of mercury sublimes as vapor, while sulphate of sodium is left—thus

$$Hg_2SO_4 + 2NaCl = Na_2SO_4 + Hg_2Cl_2.$$

A large condensing chamber is required in order to obtain a *fine* powder, and this is washed with hot water in order to remove any perchloride that may be formed.

CHARACTERS AND TESTS.—Calomel usually occurs as a heavy, dull, white powder, which is rendered yellow by trituration or by gentle heat: if sublimed in a small chamber, fibrous crystalline lumps are produced. The sp. gr. is 7.2. It has no taste, and hence its name of mercurius dulcis. It is not acted upon by hot water, ether, alcohol, or dilute acids, but potash or soda decomposes it with precipitation of the black oxide of mercury. Prussic acid also turns calomel black by causing the separation of metallic mercury. Pure calomel is entirely volatilized by heat, and warm ether shaken with it should leave no residue on evaporation (showing the absence of corrosive sublimate).

HYDRARGYRI PERCHLORIDUM—PERCHLORIDE OF MERCURY—CORROSIVE SUBLIMATE, $HgCl_2$, =271.

PREPARATION.—By subliming dry mercuric sulphate with four-fifths of its weight of dried sodium chloride, 2 or 3 per cent. of oxide of manganese being previously added to the mixture. The reaction is as follows:—

$$HgSO_4 + 2NaCl = HgCl_2 + Na_2SO_4.$$

Sulphate of soda being left, and corrosive sublimate condensing in the cooler part of the subliming apparatus. It will be noticed that the manganese has no share in the decomposition; it is introduced in order that it may set free from the excess of sodic chloride some free chlorine to combine with any calomel that may be formed, and convert it into corrosive sublimate: calomel would be formed if the mercuric sulphate contained any mercurous salt, as it is apt to do. "The fumes are extremely acrid and poisonous" (Miller).

CHARACTERS AND TESTS.—Corrosive sublimate occurs in white crystalline heavy masses—sp. gr. 5.2—it is entirely volatilized by heat, is soluble in 16 parts of cold and 3 of boiling water, soluble also in alcohol, and still more so in ether. The strong mineral acids dissolve it without decomposition. Alkaline chlorides render it more soluble in water, and hence ammonium chloride is introduced into the officinal solution of the sublimate, and it forms with it a double salt (sal-alembroth). A simple solution in water readily decomposes, calomel being precipitated, and if exposed to light and to contact with organic substances, metallic mercury separates. Ammonia gives a white precipitate of ammonio-chloride, potassic iodide produces the red iodide, potash a precipitate of the yellow

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oxide, and nitrate of silver a curdy white silver chloride. Albumen also combines directly with corrosive sublimate, and precipitates its solutions.

Liquor Hydrargyri Perchloridi—Solution of Perchloride of Mercury (*v.* p. 224).

HYDRARGYRUM AMMONIATUM—AMMONIATED MERCURY—WHITE PRECIPITATE, NH_2HgCl, =251.5.

PREPARATION.—By adding solution of corrosive sublimate to ammonia, chloride of ammonium is formed, and an ammonio-chloride of mercury precipitated—

$$HgCl_2+2NH_3=NH_2HgCl+NH_4Cl.$$

The ammonium salt is removed by washing, after filtration.

CHARACTERS AND TESTS.—This compound occurs as a heavy white powder, or in small cones marked by the linen filters: it has a metallic taste; no odor; is insoluble in cold water, alcohol, and ether; soluble in warm acids; decomposed by caustic potash, evolving ammonia, while yellow oxide of mercury is precipitated. Boiled with chloride of tin it gives a precipitate first gray and then black, from the presence first of subchloride and metallic mercury, and next of the metal wholly; this has been called the *magpie* test. "Chlorine and bromine both act violently on white precipitate, forming mercuric chloride or bromide, the action in many cases being attended with explosion. With iodine, an explosion almost invariably takes place after a few minutes: it would appear that iodide of nitrogen is formed" ("Miller's Elements of Chemistry," 1878).

HYDRARGYRI IODIDUM VIRIDE—GREEN IODIDE OF MERCURY, Hg_2I_2, =654.

PREPARATION.—By triturating together mercury and iodine in proper atomic proportions: some rectified spirit is added in order to dissolve the iodine, and to lessen, by evaporation, the heat evolved in the process.

CHARACTERS AND TESTS.—The pure mercurous iodide is a yellow powder, but according to the mode of preparation, or degree of exposure to light, becomes greenish, and olive-colored or even black; it is insoluble in water or ether; entirely volatilized when rapidly heated, but if warmed slowly in a test tube, it yields a yellow sublimate (pure mercurous iodide), metallic mercury being left: the yellow sublimate turns red on friction.

HYDRARGYRI IODIDUM RUBRUM—RED IODIDE OF MERCURY, HgI_2, =454.

PREPARATION.—By mixing together boiling solutions of iodide of potassium and corrosive sublimate: double decomposition ensues, and the red iodide is precipitated.

$$HgCl_2+2KI=2KCl+HgI_2.$$

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CHARACTERS AND TESTS.—A crystalline red powder, which becomes yellow when gently heated, and again red upon friction or after cooling: this change in color is due to a change in crystalline form, the yellow crystals being rhomboidal, the red, octahedral prisms. The salt is insoluble in water, soluble in ether and solutions of iodide of potassium. The presence of iodine may be verified by starch producing a blue color in a solution which has been digested with soda and acidified with nitric acid.

HYDRARGYRI OXIDUM FLAVUM—YELLOW OXIDE OF MERCURY, $HgO, = 216$.

PREPARATION.—By adding solution of perchloride of mercury to excess of solution of soda: chloride of sodium and water are formed, and the yellow mercuric oxide precipitates.

$$HgCl_2 + 2NaHO = 2NaCl + HgO + H_2O.$$

CHARACTERS AND TESTS.—A smooth yellow heavy powder, becoming gray on exposure to light; it is insoluble in water, readily soluble in acid, entirely volatilized by heat, being resolved into oxygen and mercurial vapor. This oxide is an allotropic form of the red oxide; it is smoother, and combines more readily with certain acids; it is better adapted for ointment used on delicate surfaces, as the eyelids, and is preferred for the preparation of oleates.

HYDRARGYRI OXIDUM RUBRUM—RED OXIDE OF MERCURY—RED PRECIPITATE, $HgO, = 216$.

PREPARATION.—By triturating and heating nitrate of mercury with an equivalent of metallic mercury: nitrous oxide gas is given off.

$$Hg2NO_3 + Hg = 2HgO + 2NO_2.$$

CHARACTERS AND TESTS.—An orange-red crystalline powder, almost insoluble in water, soluble in acids, the solution giving a yellow precipitate with caustic potash in excess, and a white one with ammonia; it is wholly volatilized by a heat below redness, and was the salt from which Priestley first disengaged oxygen (by means of a lens and sun-light).

LIQUOR HYDRARGYRI NITRATIS ACIDUS—ACID SOLUTION OF NITRATE OF MERCURY, $Hg2NO_3, = 324$.

PREPARATION.—By dissolving mercury in cold, slightly diluted nitric acid, when mercurous nitrate is formed.

$$3Hg + 4HNO_3 = 3HgNO_3 + 2H_2O + NO.$$

By subsequent boiling, this is changed into the mercuric nitrate.

$$3HgNO_3 + 4HNO_3 = 3(Hg2NO_3) + 2H_2O + NO.$$

Free nitric acid is also contained in the solution.

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CHARACTERS AND TESTS.—A colorless, strongly acid solution, from which excess of caustic potash precipitates the yellow oxide; water also decomposes the solution, precipitating oxynitrates. The presence of nitric acid is shown by the darkening of crystals of ferrous sulphate when introduced.

HYDRARGYRI SULPHURETUM—SULPHURET OF MERCURY—CINNABAR, HgS, =232 (*not officinal*).

PREPARATION—(L. P).—By melting together, with proper precautions, equivalents of mercury and sulphur, triturating the mixture, and then subliming.

CHARACTERS AND TESTS.—In dark-scarlet crystalline masses, which, when powdered, become vermilion; volatilizes on heating; on reduction with potash, the metallic mercury separates.

HYDRARGYRI SULPHAS—SULPHATE OF MERCURY, $HgSO_4$, =296.

PREPARATION.—By heating mercury with sulphuric acid, sulphurous acid gas escapes, and mercuric sulphate and water are formed, as represented in this formula:—

$$Hg+2H_2SO_4=HgSO_4+SO_2+2H_2O.$$

The mixture is then evaporated to dryness.

CHARACTERS.—A heavy white crystalline powder, which is decomposed by water into a soluble acid sulphate and a yellow oxysulphate, known as turpeth mineral.

HYDRARGYRI CYANIDUM—CYANIDE OF MERCURY, $HgCy_2$ (*not officinal*).

PREPARATION.—By dissolving 1 part of ferro-cyanide of potassium in 15 of boiling water, adding 2 parts of mercuric sulphate, heating for ten minutes, filtering, and cooling to crystallization: besides the cyanide, mercury, ferric sulphate, and sulphate of potassium are formed in this process.

CHARACTERS AND TESTS.—Rectangular prisms, sometimes transparent, generally opaque and white, taste metallic. Is stable in air, soluble in water, sparingly so in alcohol.

ABSORPTION AND ELIMINATION.—*Metallic Mercury.*—The question whether mercury can be absorbed in its *metallic* state, either by the skin or the digestive tract, has scarcely yet passed from the region of debate, and contradictory facts have been alleged concerning it. Von Hasselt found the metal in the blood of mercurialized persons (Stillé), and Colson obtained a deposit of it from a brass plate placed for a time in contact

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with blood drawn from a patient who had taken the drug (*Archives Gén.*, xii., p. 86). Claude Bernard filled the medullary cavity of a dog's femur with quicksilver, closed the perforation with wax, and allowed the soft parts to heal; three months afterward most of the metal had disappeared from the bone, and was found in small globules encysted on the surface of the lungs. In another dog the metal was injected into the jugular vein, and twenty-five days afterward found "divisé à l'infini," in the cardiac tissue under the pericardium, so that it would not remain in the blood, though taken up by it. Oesterlen used mercurial frictions on cats, giving them also internally pills of blue ointment, and he reported the finding of mercurial globules, not only in the skin, but in most of the organs. Overbeck confirmed these results on rabbits (quoted by Stillé), and Blomberg detected mercurial corpuscles in cats to which he had given pills of citrine ointment ("Treatise on Absorption of Mercury," Helsingfors, 1868). The latter observer used mercurial friction on the arm of a dead body, and found globules in the corium and mucous layers, but not deeper.

Such observations would seem conclusive, but that Bärensprung, Rindfleisch, and others find it impossible to verify them: they have made the frictions and given the pills, but they cannot find the metal in the blood, nor yet in the corium. Autenrieth could find no amalgam on plates of gold introduced into the subcutaneous tissue under the place of friction, and Gubler and Neumann, while they recognized the metal in the sweat-glands and hair-follicles, could trace it no further. Rindfleisch, it is true, found mercury once in mesenteric glands after giving mercurial pills, but there were ulcerations in the intestinal mucous coat which might have permitted the passage of the metallic globules (*Archiv für Dermatol.*, iii., 1870). The most recent observations are those of Fleischer, who concludes from numerous experiments, that "frictions with mercurial ointment cause the penetration of metallic particles into the superficial layers of epidermis, but not deeper:" and a consideration of the whole evidence warrants this negative conclusion, that although metallic mercury, when administered by the mouth in substance, or actually placed within the tissues, may circulate and be deposited, it does not seem to be altered or absorbed in the ordinary sense, and when applied by friction it usually does not pass either into the deeper tissues or into the blood.

The physiological effects of mercurial frictions must be connected, therefore, with its absorption in some other form: either mercurial vapor is inhaled during the process, or a sebacic oxide of mercury enters through the skin. As to the former point, we know that sometimes salivation has occurred in a wife, six hours after a friction made by the husband upon himself only, both living in rather a small room (Samelsohn, quoted by Hallopeau); and additional evidence in favor of such an effect is furnished by the delicate observations of Merget. He demonstrated that mercury

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volatilized at all temperatures, and, by means of iridium-paper (which showed a dark stain on contact with the vapor), he proved its presence on the hands or other parts of the body of persons who had spent only a few hours in a workshop where it had been used (*Comptes Rendus*, December, 1871). That the mercurial vapor is not absorbed *only* by the lungs is evident from a carefully devised experiment by Fleischer (Erlangen): he caused frictions to be made upon an arm while the patient—with face covered by a mask—breathed only external air; the limb was then carefully wrapped in wool and oiled silk for sixty hours, and during that time the presence of mercury (in very small quantity) was verified in the urine.

We may state then that mercurial *vapor* is absorbed, not only by the lungs but also by the skin, and indeed the results of ordinary fumigations—when the head is external to the apparatus—would be sufficient to prove this. Gubler holds that the sweat-glands are the active agents in this absorption, and Röhrig admits that mercury in vapor can pass through the epidermis (Stricker's *Jahrb.*, ii. 1873). It is probable also that some may be absorbed as oxide in combination with fatty acids (sebacic), or acids contained in the perspiration (Christison). Bärensprung and others have proved the presence of such oxide in "blue ointment;" Nevins calculated it at 1 part in 100, and Voit, analyzing portions of skin which had been rubbed with it, found the oxide constantly present. A soluble double salt may be formed with the chlorides of the perspiration (Müller), and, if mercurial oxides be given internally, Voit argues that the chlorides of the blood can change suboxide into calomel and peroxide into perchloride, which salts then combine with sodium chloride and albumen.

Metallic mercury, *given by the mouth*, usually passes off unchanged by the bowel; in the rare cases where it has given rise to constitutional effects, a portion has probably been oxidized or changed into sublimate. In the very finely divided form, when the metal is "extinguished" by continued friction with chalk (gray powder), or with confection of roses (blue pill), Rabuteau thinks it may be directly absorbed from the intestine, but no doubt some oxidation occurs during trituration, and the oxide would be soluble more readily in the acid of the gastric juice; mercury in a volatile form would also be disengaged from such compounds as readily within the body as without, at the same temperature. Mercurial ointment or pill, introduced as a suppository into the rectum, produces physiological effects perhaps more quickly than by the stomach. In the various trades which require the handling of quicksilver—such as barometer- and mirror-making, gilding, and skin-dressing, and again, in miners at Almaden and elsewhere—the physiological effects produced are mainly traceable to inhalation of the vapor.

Calomel.—Calomel being not only insoluble, like metallic mercury, in

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ordinary liquids, but being also non-volatile, there has been still more speculation as to how it could reach the current of the circulation.

According to the classic theory of Mialhe, it becomes, like other mercurial compounds, changed more or less into the soluble *perchloride* by the action of the gastric fluids, and is absorbed only to the extent of such change. Mialhe argued from the results obtained by heating together calomel and ammonium chloride in a test tube, but Buchheim and others failed to verify any formation of perchloride in such a mixture at the *temperature of the body.* Rutherford, experimenting more recently, digested 5 gr. of pure calomel in distilled water, with .02 per cent. of free hydrochloric acid—(the same proportion as in gastric juice)—at 100° F. for seventeen hours, and obtained $\frac{1}{35}$ gr. of perchloride, but it is unlikely that even so much as this would be formed in the stomach; and the action of calomel so far differs from that of corrosive sublimate as to render it, clinically speaking, improbable that it only depends upon some formation of the latter. Rabuteau, however, maintains that calomel does become changed into perchloride and metallic mercury; also that this perchloride combining with soda salts forms chloride of sodium, and sets free more of the metal—that under the influence of such changes the compounds are absorbed—acids and alkalies being afterward eliminated, and the metallic mercury in part deposited. In this view, though complex, there seems some analogy with what is known of the behavior of salts of gold, silver, and some other metals, and calomel certainly resembles in action preparations of metallic mercury—otherwise we have no proofs of such direct absorption of it, but rather the reverse.

Various observers have directed attention to the possibility of calomel being rendered soluble in other combinations, *e.g.*, with albumen (Buchheim), or as a double salt formed with chlorides of the blood (Graham). Headland pointed out that *bile* exerts some solvent power on calomel (*Lancet*, i., 1858), and Gubler asserts that an excess of various organic materials—*albumen, mucous, epithelium*—acts similarly; some limit, however, must be placed to this observation, for the excess of mucin in the stomach of a dog entirely prevented the absorption of calomel that had been injected into the stomach (Rutherford, Exper. 38). An experiment of Tuson's is more to the point: he placed in one vessel calomel with dilute hydrochloric acid, and in another the same mixture with a proportion of *pepsine:* after digestion for an equal number of hours sulphuretted hydrogen was passed into the solutions and produced a black precipitate in that with pepsine, but none in the other, proving clearly the effect of the organic subtance in promoting the solution of the calomel (*Medical Times*, i., 1872, p. 518). Jeannel pointed out the importance of *fatty* matters for the solution of calomel: in the presence of an alkaline carbonate, it is readily decomposed with precipitation of gray oxide; of this latter a *small* proportion is retained in solution by the water, but if a fatty

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oil be mixed with the alkaline solution, this proportion is very much increased: the same might readily occur in the intestine (Abstract: *Schmidt's Jahrb.*, 1869, Bd. cxliii., s. 9).

It is quite possible, as H. Wood remarks, that in consequence of the varying composition of the intestinal fluids and the complex chemical relations of calomel, its solution and ultimate absorption may be accomplished in several ways: when more chlorides are present some perchloride may be formed, and when sulphuretted hydrogen is in excess it may produce some amount of soluble sulphide.

Dr. Law, of Dublin, was the first to notice how much the absorption of calomel could be promoted, especially in severe illness, by minute subdivision of the dose, giving, *e.g.*, $\frac{1}{12}$ gr. every hour (*Dublin Quarterly Journal*, xiv., p. 393). Trousseau amply corroborated this observation, and it is, *à priori*, reasonable, for the smaller quantities more readily come in contact with the intestinal fluids to form the double salts or soluble compounds described.

Bellini indicated a difference in the mode of absorption of calomel according to the condition of the stomach: thus, when taken fasting, only a small amount was at first dissolved, with formation of double chloride of mercury and sodium, and lactate of mercury; more was dissolved in the *intestine*, under the influence of alkaline carbonate, an oxide of mercury being at first formed, and then a double salt; in the large intestine a sulphide was formed (except in the case of infants). Introduced into the stomach *during digestion*, it was wholly, or almost wholly, decomposed under the action of *proteinous* substances, metallic mercury being formed and a soluble albuminate.

From the cellular tissue some calomel may be absorbed, since constitutional effects have been produced by its *hypodermic* injection when simply suspended in liquid, but the major part remains unabsorbed, and frequently causes abscess.

Corrosive Sublimate.—The absorption of corrosive sublimate may be realized without much difficulty, because it is soluble in ordinary fluids; an albuminate of mercury may form in the stomach, but is probably not absorbed as such: the formation of a double salt with sodium is more likely, and the same occurs with iodides and bromides of mercury: saline or albuminous solutions of perchloride and aqueous solutions of cyanide are also readily absorbed from the cellular tissue.

The chlorides and iodides may also be absorbed from blistered surfaces (*endermic* method), and probably then also, double salts with albuminous and alkaline constituents of the serum are formed.

Elimination.—Although we cannot state positively the form in which mercury circulates or is deposited within the system, whether in a volatile form at first, or as very finely divided metal, or oxide, or as an albuminate, or (which is more probable) as a double chloride with soda or

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ammonium and albumen, yet we can be satisfied of its detection under certain circumstances, in every organ, and in every secretion. With the *blood* it seems so closely associated, that destructive distillation is usually required for its detection, and in the *milk*, and even in the *urine*, there has been difficulty in finding it, so that some observers have reported against its presence (Köhler: *Practitioner*, vol. xvii.; Cullerier: *British and Foreign Review*, ii., 1852), but the more modern researches of Personne, Binz, Hamburger, and others, can leave no reasonable doubt on the subject. Heller detected mercury in the fœtus borne by a salivated mother, and in the urine of an infant whose nurse was taking calomel. Sometimes, however, it may not be discovered after inunction, though readily after the use of mercurial suppositories (*Prag. Med. Woch.*, iv., 1877; *Lancet*, ii., 1877). (The modern and accurate method of detecting mercury is by electrolysis.)

The question of its *elimination by the milk* is one of much importance, for large establishments have been formed in Paris for the treatment of syphilitic infants especially, through the milk of nurses or of goats that have taken mercury: such treatment is constantly adopted with good result, and there is abundant clinical evidence of its value. With regard to the time during which mercury remains in the system, it is ascertained that of a single dose elimination is rapid, and is apparently completed within twenty-four hours; for $\frac{1}{6}$ gr. of perchloride having been taken, the urine contained traces for that period, but not afterward; and .075 gramme (about 1 gr.) having been injected under the skin of a rabbit, none could be discovered in any part of the body four days afterward (Mayençon and Bergeret: *Robin's Journal of Anatomy*, No. 1; *Lancet*, i., 1873). M. Byasson injected $\frac{1}{3}$ gr. of sublimate under his own skin, and found mercury in the urine two hours afterward, and at the end of four hours in the saliva, but after twenty-four hours he detected no more. If treatment have been continued for some time, mercury may be found in the urine for several days afterward; thus, in the urine of two patients who took $\frac{1}{6}$ gr. daily for ten to twelve days, the drug was found for four or five days after treatment had been omitted.

During a mercurial course, the greater part of the drug is eliminated almost as soon as taken, but some remains in the tissues and passes out insensibly; and when the doses have been large and long-continued, some may be retained in the organism for months or even for years. It is, in fact, impossible to recognize exactly when its elimination is complete, though it is probably not so prolonged as that of gold, lead, or silver (Husemann). Years after its prolonged administration, unusual perspirations may develop dark mercurial stains on the linen, or a white coating be given to a piece of copper on handling it (W. Pope, quoted by Stillé). Salivation may reappear without apparent cause (unless a chill); sometimes it has been traced to the use of sulphurated mineral waters,

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and occurred in one patient ten years after taking the medicine (Hartung, quoted by Hallopeau). I have myself seen five patients, while under the influence of nitric acid, suffer from salivation and other physiological symptoms of mercury, and none of these had taken that drug for over eighteen months previously: I considered it clearly traceable to the mercury in the system, and not to the acid. The metal has been found in the liver of a workwoman who had not, for twelve months previously, been exposed to mercurial vapors, and in the liver and kidneys of another who died of phthisis six months after leaving her work at a mirror factory (Küssmaul, Gorup Besanez: *Wien. Med. Woch.*, 1862).

Melsens pointed out (1844) that iodide of potassium favored the elimination of mercury as well as of lead, and in many cases it has been found that elimination, which had ceased, has been renewed under the influence of the iodide; yet this influence is not always sufficient to complete the process, for Küssmaul found a quantity of mercury in the viscera of a patient who had taken none for four months, and who, in the course of a month, had taken 2 oz. of the iodide.

Riederer has made experiments to ascertain the *quantity* of mercury that may be found in different organs or secretions: of about 10 gr. of calomel given to a dog in thirty-one days, he recovered four-fifths—the largest proportion from the fæces, the next from the urine, the liver, the thoracic viscera and brain, and the least from the muscles (quoted by Hallopeau, p. 58). Other observers agree that on section of an animal subjected to the action of mercury, the largest amounts are found in the liver and kidneys (and not in consequence of their containing more blood than other viscera, for the blood contained a much less proportion of the drug); it must therefore be considered to have a special determination to the liver and kidneys, and it is eliminated mainly by the bile and the urine; in this respect it resembles other metals.

Physiological Action (External).—The local action of mercury varies according as to whether the metal itself is used, or one of its soluble or insoluble compounds, and of course according to the strength of the preparation; and on account of the volatility and the ready absorption of the drug, its local use often induces its systemic effects.

Metallic mercury produces upon the skin no other local effect than a sense of coldness. Mercurial ointment applied by friction is usually well borne, but sometimes excites a red or vesicular eruption (mercurial eczema), more or less intense; ointment of the red oxide is painful to sensitive parts, and that of the red iodide may irritate very severely, even to vesication: if not perfectly fresh an additional source of irritation is found in rancid lard: good calomel ointment is rather soothing than otherwise.

A strength of 2 gr. of corrosive sublimate in the ounce of liquid suffices to destroy parasitic life; a stronger lotion irritates. Cloquet, the

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distinguished anatomist, suffered from severe local and general symptoms after handling some preparations steeped in a strong solution. A proportion of 10 gr. to the drachm of alcohol vesicates, and when applied to the scalp has caused death in a child (*Lancet*, ii., 1871). In two other children, the use to the scalp of an ointment containing 120 gr. to the ounce of tallow also caused death (*Dublin Journal*, August, 1854). The solution of the metal in nitric acid (liquor hydrargyri nitratis acidus) is a powerful and painful caustic, and its application has sometimes, though not frequently, been followed by severe general symptoms: it combines with albumen and fibrine, producing a white eschar.

On the mucous membrane of the intestinal tract mercurial compounds may exert a *local* action of the same nature as upon the skin. Quicksilver, in doses of ½ oz. or more, will usually pass through the intestine by its mechanical weight, and unaltered; sometimes it has caused perforation.

Physiological Action (Internal).—In studying the action of this medicine, it is more than usually important to distinguish between the effects of *small* and of *large* doses. Modern observation shows us that the former are rather of tonic and constructive character, while older records have told us only too well the fatally destructive results of the "heroic" administration of the drug. I do not mean simply that one grain, *e.g.*, of calomel has a different effect from twenty: we must estimate the dose rather by what is absorbed of it, and by the results shown, especially by the state of the mouth and the secretions. Practically we can either give the medicine so as to cure without marked effect upon these, or so as to produce only moderate effects, and it is this "slight mercurialization" which requires to be distinguished from the severe form which should be called rather mercurial poisoning, and is accompanied with stomatitis, salivation, diarrhœa, cachexia, etc. A similar difference of degree exists, of course, in the action of all powerful medicines, but it requires more attention in the present instance, because our predecessors thought to give benefit only by what we consider a poisonous action of the drug, and it consequently fell into undeserved discredit. There is, further, a chronic form of mercurial poisoning which may still be met with in various trades, and this differs in some respects from any condition produced by modern medication.

Circulatory System.—Recent observations as to the action of mercury on the blood illustrate well its different effects, since they show that, in quite small doses, it increases the number of red corpuscles, and improves the blood-condition. Grassi proved this by analyses, and Wilbouchewitz counted carefully under the microscope the average number contained in a millimetre-cube, and his patients (ten in number) then took either ⅛ gr. of sublimate daily, or ¼ gr. of proto-iodide: during the first fortnight of treatment the increase of corpuscles amounted to nearly one million.

These patients were syphilitic, and probably the anæmia of their

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malady was benefited by the antidotal action of the mercury, for the remedy being continued beyond a certain time (and thus allowed to accumulate in the blood), the red globules diminished in number, so that, by the end of the second fortnight, they counted the same as before any treatment. Mercury being then omitted altogether, the corpuscles increased again within a week's time. The inference is clear—*too much* of the drug impaired the blood-condition, but a *little* improved it. When it was omitted, and when, after a few days' time, only a small proportion remained in the blood, the original improvement was again observed: the white globules varied in an inverse ratio (*Archives de Physiologie*, 1874). Keyes repeated these observations, and concluded that small doses of mercury increase the blood-corpuscles *in all subjects*, whether syphilitic or not; and further, that this increase is not temporary: he has never seen hypoglobulism—*i.e.*, a lessened average number of corpuscles, caused by small doses (*American Journal*, January, 1876). Possibly the difference between these two observers may arise from difference in dosage, Wilbouchewitz giving the rather large quantity of "$\frac{1}{3}$ gr. sublimate daily;" no doubt mercury in any form, continued long enough, and absorbed, will produce a *destructive* effect on the corpuscles, and a condition of "spansemia." Long ago, Bretonneau and Dumont reported that the blood-clot in mercurialized animals was either absent or was soft and diffluent. Headland's expression is that mercury "disintegrates and decomposes the blood" (*Lancet*, i., 1858), and Wright's analysis showed it to be more fluid and less coagulable than normal, its albumen, fibrine, and red globules being diminished, and a fœtid, fatty material being formed in it. Gubler has also corroborated this destructive effect, and yet Lemaire and Gelis found "mercurial treatment to increase plasticity of blood." Autenrieth questions the analysis of Wright, and more lately Overbeck found in animals poisoned by mercury the venous blood dark and thick, the arterial blood clear and coagulating well, fibrine increased: probably these results were connected with inflammatory reactions, but, if verified, they tell much against any available "aplastic power" of mercury in inflammation; still, the *ultimate* effect of the drug is destructive. Polotebnow, adding mercurial albuminate to the blood of dogs, found the corpuscles rapidly destroyed, with loss of hæmatine and pigment (Schmidt's *Jahrb.*, 1865, 125, 3). Wilbouchewitz, giving calomel to rabbits (and not in large doses), noted a rapid diminution of corpuscles. Trousseau found that leech-bites that had ceased bleeding, bled again in patients submitted to mercurial treatment, but beyond any single fact is the general experience that too much of the drug induces—after a period of malaise, restlessness, and febrile symptoms—a chlorotic pallor of the skin, with signs of enfeebled circulation, distress in breathing, intermittent pulse, and palpitation; such a condition, when fully developed, is difficult of cure; it may last long, and end fatally.

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Fothergill includes mercury among his "cardiac depressants," and G. Harley, having injected sublimate into the femoral vein of a dog, found that cardiac paralysis was produced before intestinal contractions ceased ("Proceedings of the Royal Society," 1864).

Nutrition.—Nutrition is so closely connected with hæmatosis that we shall be prepared for the modern observations that it also may be improved by *small* doses of mercury. Keyes found this to be the case—the *weight* of his subjects increased under their course, and the remedy acted "as a tonic." Hufeland had previously made a similar observation, and Basset, Liégeois, and others corroborate it: the last-named observer considers sublimate in minute doses "comme un réconstituant des plus puissants" (*Annales de Dermatol.*, i., ii., 1870), and M. Clerc reports the same experience (*Gazette de Paris*, 1872, p. 481): it has been verified also, independently of syphilis, on animals, and especially rabbits.

On the important question of *urinary excretion* the principal evidence is negative. We need more research in this direction, but so far the evidence does not favor the theory of mercury (in small doses) curing disease by *increase* of tissue-change—that it lowers the temperature in animals (except during the stage of "erethism"), and that it does the same in fever (Wunderlich), I should take as evidence of its *lessening* change, rather than the contrary, as Husemann does. Altogether, at least in the doses under consideration, mercury merits the name of "moderator of nutrition," rather than of alterative (Rabuteau); and in this rôle we can see its analogy with small doses of arsenic, antimony, etc., under which, as is well recognized, weight may be gained, and nutrition improved. Under full or poisonous doses, when the blood-corpuscles are destroyed, the secretions are rendered profuse, and digestion impossible, nutrition is, of course, profoundly impaired, and waste of tissue progresses most rapidly.

Digestive System.—Small (therapeutical) doses of any preparation are usually well borne by the stomach. Rabuteau cites cases where many hundred pilules of proto-iodide have been taken in the course of one to three years without any gastric disturbance: yet we must allow for some idiosyncrasy in this respect, and practically we find that those who have resided long in the tropics, and fair, delicate women and chronic dyspeptics are very sensitive. It is not, however, possible to say beforehand what amount of mercury will produce the characteristic effects on any given case—a single friction or a few grains may produce in one patient what many weeks of treatment will not do in another. Single doses of calomel—from 1 to 5, 10, or even more grains—produce thin and "bilious" stools without much griping. If the intestine of an animal be examined after such actions, it will be found reddened, especially in the upper part, and its glands stimulated. As a rule, ordinary care will early detect symptoms of constitutional action in the mouth, such as a sense of heat,

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metallic taste, sticky coating of the tongue, increased flow of saliva, and perhaps slight tenderness of the gums. On continuance of the medicine, these latter symptoms increase and diarrhœa occurs, with some nausea. The stools, at first feculent, become thin and sometimes papescent with mucus, sometimes yellow, or dark or grass-green (the latter especially in children: they have been compared to "chopped spinach"): sometimes blood appears in the motions, and severe colic and tenesmus occur. The tongue is said to show a greenish coating with two longitudinal red stripes (Traube). In severe cases, when the poisonous action of mercury has been induced, intense stomatitis appears, with swelling of the tongue and gums, membranous deposit, fetor, loosening of teeth, and severe pain and difficulty in mastication. The salivary glands become enlarged and tender, and a vast amount of secretion pours from the mouth: 10 lbs. of it have been secreted in twenty-four hours: at first viscid as usual, it soon becomes thin and very watery, containing albumen, mucus, and alkaline chloride (Thompson). Children and the aged are seldom salivated—Graves suggests because their salivary glands are "inapt"—diarrhœa or prostration is with them the earliest symptom. Salivation is connected, too, with local causes: it comes on more quickly when the mouth is unclean, and may be almost wholly prevented by great care with the teeth: dental caries will determine it; it is said to commence by the last molar of the side on which the patient mostly sleeps (Ricord): also the irritation of a wisdom-tooth, or of a pipe, will influence it.

Such facts have led to the supposition that salivation is only *secondary* to buccal soreness, but this is incorrect: it may be induced by rubbing mercury over the parotid, and *before* any irritation is produced. Ricordi detected the drug in saliva drawn from Steno's duct, by a catheter, in animals, when calomel had been injected beneath the skin; and salivation occurs, as we know, independently of mouth-irritation from the action, *e.g.*, of gold, iodine, various acids, etc., as well as during pregnancy and certain diseases. The safe test of a mercurial salivation is detection of the metal in the secretion. Women seem to be more readily affected in this way than men, and the subjects of granular kidney, of scrofula, and of scorbutus are peculiary susceptible (Christison and others). It occurs more frequently under fractional (non-purgative) doses of calomel, or inunction of blue ointment, than from fumigation, suppositories, or injections: it is markedly less under the use of sublimate, iodide, or cyanide, than of insoluble preparations, either on account of the smaller dose of the former employed, or of some peculiarity in their elimination. Ulceration, or sloughing of the gums, hemorrhage, periostitis, and prostration of even fatal character have occasionally followed a profuse salivation, and necrosis, scars, and contractions have accompanied even recovery.

We have seen that a local action, irritant in character, is exerted by

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most compounds of mercury on the alimentary tract; but H. Wood speaks of calomel as "free from all irritant properties," and Lente argues that large doses (one teaspoonful) act in a sedative manner (*New York Journal*, 1870, vol. xi.)—this was the argument of Annesley, but it is not a safe one to act upon. The irritation excited by corrosive sublimate in toxic doses is, however, the most severe: there is an acrid taste, and a sense of burning and constriction in the mouth and fauces, with whitening and shrivelling of mucous membrane if the dose be concentrated: vomiting and purging with tenesmus usually occur, with passage of blood, suppression of urine, and general symptoms of gastro-enteritis: after death, signs of inflammation, contraction, or ulceration have been found, especially in the stomach and upper part of the intestine, and that this is not merely a local effect is proved by its occurrence when the drug has been administered by the skin. Profound depression is usually a symptom of sublimate poisoning, and is sometimes more marked than pain, vomiting, or purging; salivation is by no means constant in acute cases.

The iodides of mercury act much like corrosive sublimate, the red iodide being more actively irritant than the green one. The red oxide produces similar lesions of the intestinal canal (Orfila); it is not given internally in medical practice, nor is the ammonio-chloride (white precipitate), but in a case when a large quantity of the latter compound caused death, the stomach was found contracted, and its lining membrane ecchymosed (*Guy's Reports*, 1874). The liquor hydrargyri nitratis has produced intensely severe effects on the intestinal tract, and irritant poisoning has followed the accidental use of the sulphides and the cyanide of mercury.

Glandular System, Liver, etc.—Most of the glandular organs are liable to become congested, and stimulated under the influence of mercury. This has been noted not only of the salivary glands as already described, but also of the pancreas and intestinal glands, the kidneys and the liver, the testis and lymphatic glands of axilla and groin (C. H. Jones: *Medico-Chirurgical Transactions*, vol. xxxv., etc.). As illustrating the effect on the pancreas, Dr. Copland recorded a case, where, in addition to salivation, deep-seated epigastric pain set in, with nausea and diarrhœa of thin fluid resembling saliva; after death the gland was found large and congested. Radziejewski found, on analyses of the stools after giving calomel, a large proportion of leucin, tyrosin, and indol (pancreatic secretion), which he did not find after other purgatives (Reichert's *Archiv*, 1870). That calomel also stimulates the intestinal glands has been demonstrated by Rutherford.

The mode of its action on the liver is still a subject of discussion, and the conclusions of some physiologists on this subject are opposed to those of many practical physicians. Up to a recent period, mercury was uni-

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versally regarded as a typical "cholagogue," in the sense of its stimulating both the secretion and the excretion of bile, and hence was commonly employed, both in cases of deficient secretion to stimulate, and in cases of excessive secretion to "carry off" the excess.

The early experiments of Murray were taken to corroborate the theory of "cholagogue" action, for, after giving purgative doses of calomel to dogs, he found increased discharge of bile, mucus, and serum from the bowels (quoted by Morehead, 1841). Buchheim also reported an increase in the amount of bile discharged by dogs with biliary fistulæ. Still more important evidence was furnished by the analyses of Michéa, which were made first upon the normal stools of six healthy subjects without detecting bile; then, with nearly like result, upon the green stools of persons suffering from diarrhœa; then upon the greenish motions which occurred in eight healthy persons after taking calomel, and in all of which bile was clearly detected; and lastly, upon discharges produced by different saline and resinous purgatives, and in which no bile was found (*Lancet*, i., 1849). Although these observations show an increased *discharge* of bile under calomel it is clear that they do not necessarily prove an increased *secretion* by the liver-cells, and therefore experiments on animals as to this point were undertaken. Kölliker and Müller, after giving calomel to dogs with biliary fistulæ and collecting the bile discharged, reported contradictory results—the secretion being in one instance increased, while in two others it was diminished (1855). Scott, experimenting with large doses of calomel on four dogs (also with fistulæ), recorded diminution of both fluid and solid biliary constituents in all the animals (Beale's *Archives*, i., 1858). Mosler, with two dogs, obtained a similar result (Virchow's *Archiv*, xxxii.); and Hughes Bennett, reasoning from the experiments of the Edinburgh committee, announced, as a positive fact, that mercury really *lessened* the biliary secretion in man as well as in animals (1868). The experiments on which this physician founded his important conclusions require a brief consideration: they were made upon forty-one animals, and on account of difficulties in the operations, etc., results considered satisfactory were only obtained in nine instances—in four of these calomel was used: a permanent fistulous opening into the gall-bladder was very carefully effected, and about fourteen days afterward the bile was collected on a sponge. The first dog, before taking any drug, secreted a daily average of 82 gr. bile-fluids, and 5 gr. of bile-solids; after taking 4 to 12 gr. calomel daily, it secreted only a daily total average of 60 gr.; but it must be noted that the animal's condition was much impaired, it took little food, and soon afterward died. The second dog got smaller doses ($\frac{1}{15}$ gr.) every hour; the general health became affected, and it soon died: the average bile-secretion was about the same, before and after giving the drug. The third dog received some blue pill in addition to the small doses of calomel, and the bile-average

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was diminished one-half; the animal suffered much. The fourth dog got purgative doses, with an average bile-diminution while under their influence; on one day, however, when blue pill was given, the average was increased (*British Medical Journal*, i., 1869). Such results scarcely warranted Dr. Bennett's conclusions, which were, indeed, publicly controverted by Christison, Fraser, and other members of the same committee. Röhrig (of Kreuznach) reported that large doses of calomel slightly increased the bile-secretion (Stricker's *Jahrb.*, ii., 1873), but we may take the more recent experiments of Rutherford and Vignal as showing, so far as experimental research can show, that the drug does not really do so. They proved (1) "that doses of 10 gr., 5 gr., or 2 gr., several times repeated, placed (without bile) in the duodenum of a fasting dog, produced a purgative effect varying with the dose, but so far from increasing bile-secretion, usually diminished it; (2) that there is no difference in the result if the calomel be given in 1-gr. dose, several times repeated, mixed with bile and introduced into the duodenum" (*British Medical Journal*, ii., 1875–76; *Practitioner*, December, 1879). On the other hand, the same observers found that *corrosive sublimate* in doses of $\frac{1}{8}$ and $\frac{1}{16}$ gr. powerfully stimulated the secretion of bile, while it did not stimulate the intestinal glands (*British Medical Journal*, ii., 1877). They further instituted experiments which showed that calomel does not become changed into *corrosive sublimate* to any appreciable amount under the influence of the organic secretions. Rutherford himself notes that the experiments referred to do not prove anything as to the action of mercury on the *bile-expelling* apparatus, and we may grant that they are correct without any denial of the clinical fact that a purgative dose of calomel will increase the amount of bile discharged by the bowel; it may do this, not necessarily by a previous stimulation of the liver, but either by irritating to unusual contraction the gall-bladder and gall-ducts, or by lessening a congested condition of these parts, through the discharge induced from intestinal glands.

Dr. Lauder Brunton has further pointed out that the clinical fact of calomel relieving "bilious conditions," receives from the experiments of Schiff and Lusana an explanation not at all inconsistent with Rutherford's conclusions (*Practitioner*, vol. xii.); these experiments go to prove that the liver not only *secretes* bile, but also *excretes* it, separating from the blood a part of that which (normally) circulates in it: for after effecting biliary fistulæ in animals, bile flowed at first freely—afterward, in much diminished amount, independently of any drugs. This diminution was accounted for by the passing away of bile so soon as formed, and the consequent impossibility of its being reabsorbed from the duodenum into the circulation, to be again excreted, for if *fresh* bile were passed into the blood by intravenous or cutaneous injection, then the amount of excreted bile was again increased. Schiff further showed not

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only that bile can thus circulate without giving rise to jaundice, but that it probably always does so, passing from the liver to the duodenum, thence into the blood, and so to the liver again, a portion only, more or less changed, passing out by the fæces.

This tallies with the observation of Murchison, that "by increasing the elimination of bile, and lessening the amount circulating in the portal blood, mercury is a true cholagogue, relieving the liver thus, more than by merely stimulating it to increased secretion" (*Lancet*, i., 1874). The green, liquid, spinach-like stools produced by calomel have been variously attributed to intestinal irritation, to altered hæmatin (Golding Bird, 1845), and to subsulphate of mercury (Thudichum); it is possible that they may contain sometimes mercurial compounds, but they certainly often contain bile. According to Simon's analysis of the fifth stool passed after a large dose of calomel, it was fluid, green, without fæcal odor, of acid reaction, and contained mucus and epithelial cells, fat, cholesterin, bilin, and bile-pigments—no mercury whatever ("Animal Chemistry," vol. ii.).

Genito-Urinary System.—Women affected with mercurialism are liable to abort (Colson, Lizé), yet it is equally proved that syphilitic women should be treated with medicinal doses, for in such doses mercury may save them from abortion (M. F. Weber, 1875). The influence on menstruation is not constant; generally, this will be diminished, but sometimes much increased.

Lusana found that mercurialism in fowls prevented the laying of eggs, and Gaspard, that the vapor of quicksilver prevented eggs from coming to maturity.

Small (therapeutical) doses exert no marked effect on the kidneys, but we have seen that the drug is largely eliminated by those organs. Overbeck, indeed, found leucin and results of disintegrated albumen in the urine of animals (Husemann), but E. R. Harvey, experimenting on dogs, found the *quantity* of urine unaffected, the phosphates always diminished, the urea not increased beyond a normal variation (*British and Foreign Review*, i., 1862). Von Böck could find no definite change in the excretion of nitrogen or uric acid (1869). Bouchard reported a diminution of urea, but his patient had uræmia (1874); and more recently, Conty, after observation on twelve syphilitics, taking therapeutic doses of proto-iodide, could verify no definite alteration. During pronounced mercurialism albuminuria may occur with or without hæmaturia (Pavy, Overbeck, Küssmaul). After death, congestion and fatty degeneration have been found (Balogh and others); and Ollivier has pointed out the analogy between such conditions and those produced by lead.

The albuminuria does not necessarily imply altered renal structure, it may be dependent only upon general dyscrasia and loading of the blood with organic débris (Gubler), but, in severe or prolonged cases, stea-

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tosis is very probable. Bouchard has recorded two important illustrations; in one case of acute mercurialism, five days after salivation had commenced, suppression of urine occurred, and on the ninth day the patient died comatose, and a very large amount of urea was found in the blood, almost proving that uræmia was the cause of death. We have not details of the second case, but in both the Malpighian bodies were found to contain, or to be changed into, mineral matter, proved to be carbonate of lime (Hallopeau, p. 113). This condition is very interesting when compared with Salkowski's results in rabbits; he injected fractional doses of sublimate, of iodide, and of calomel, and after death, found constantly lime and soda deposits in the Malpighian bodies; the urine became pale and contained sugar. Cornil also found calcareous deposits, and Kletzinski reported diabetes.

Nervous System.—From the medicinal use of mercury we seldom see definite effects on the nervous system, beyond a temporary malaise, chilliness, depression, or erethism; the severe symptoms of neuralgia, tremor, convulsion, or paralysis are met with only in persons exceptionally, or for a prolonged period, exposed to its action, such as those who work with it and suffer from a "chronic mercurial poisoning." A grain of calomel or blue pill has been taken every night for more than forty years without other than good effects apparently, for one cannot argue much from fatty degeneration, at the age of seventy-four (*Medical Times*, ii., 1867). On the other hand, tremor has developed in one night under the influence of strong mercurial fumes (Christison), but, as a rule, the slow and continued absorption by the skin and the lungs of metallic quicksilver or its vapor is the cause of symptoms such as those we are now considering. Anstie pointed out that sensory nerves were sometimes affected by it, "a selective affinity" being shown for the fifth, whence an attack of severe and persistent facial neuralgia; but severe pain may also affect the head generally, or all the limbs (*Lancet*, ii., 1872); the pains are usually made worse by warmth; tingling or other alterations of sensibility may be experienced; there may be partial anæsthesia or analgesia which either varies, as in hysterical subjects, or may be permanent; abnormal sensations of cold are also described. Tremor is the most constant symptom of chronic mercurialism: all the workmen in mercurial mines suffer from it, and sometimes it is the only symptom apparent, there being neither salivation nor erethism: it commences usually in the lips and the tongue, and soon affects the upper extremities; it is most marked, like the tremor of sclerosis, under the influence of voluntary movements, or of fatigue; it may exist in all degrees up to severe convulsive movement affecting the whole body (called "calambres" at Almaden): slight cases of tremor are curable in a few weeks; more serious ones last for months or years, and yet the subjects continue to walk and to work. The tremors cease during sleep, and also, it is said, during intoxication; this is an interest-

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ing fact, as also is the transmission of the malady by inheritance, so that children are born in the state of tremor.

The phenomena of exaggerated action pass, after a time, into those of paralysis, so that one or more muscles may cease to answer properly to the will, though muscular power is retained (as in locomotor ataxy); the extensors are often affected: sometimes the paralysis is temporary, and of hemiplegic character; electro-muscular contractibility is preserved, but atrophy of muscles may occur.

It remains to note the *mental* condition in chronic mercurialism: emotional sensibility is generally heightened, the patient is timid and easily excited, intelligence is weakened, and a delirious condition (like that of delirium tremens) occurs in paroxysms; sleeplessness is marked. We cannot say that true epilepsy is produced, though the convulsive attacks may have been called by that name, but giddiness and noises in the ears, muscæ, nausea, and tendency to fall, constitute a condition resembling at least "petit mal." It is not likely that apoplexy can be directly connected with mercurial poisoning.

With regard to the *pathology* of the nerve-symptoms described, Anstie suggested that the cortical gray matter was mainly affected. Ross, in his able paper, seems to think that an effect on the connective tissue of the nerves would explain it (*Practitioner*, 1870). Mercury has been found by analysis in the brain, but we can scarcely consider its effects to be directly and locally poisonous to the nerve-cells: we may gain some light from the changes discovered in cases of alcoholic or saturnine saturation of the nervous centres, and those we find to be mainly chronic inflammation and fatty degeneration (Lancereaux, Vulpian).

Cutaneous System.—We have spoken of the local irritation that may be excited by mercurial frictions. There may be merely erythema with much itching, or an eczematous (vesicular) rash, or even erysipelas and gangrene (Stillé). The internal use of mercury may also, exceptionally, give rise to eruptions, of which Bazin has distinguished three forms, "hydrargyria mitis, febrilis, and maligna," showing either a simple efflorescence about the thighs, the scrotum, abdomen, and axillæ, or a more intense form with vesicles, or one still more severe with general œdema and purpuric rash. The general symptoms in such cases may be serious: desquamation occurs in the milder forms about the eighth or tenth day; malignant forms (which I have never seen) may give rise to adenitis, abscess, or ulceration. Occasionally, owing to idiosyncrasy, a scarlatinoid rash may be excited by a single dose, as by $\frac{2}{3}$ gr. of proto-iodide in a case recorded by M. Fournier (Hallopeau): one application of acid nitrate produced the same effect, as also did a few Dupuytren's pills ($\frac{1}{6}$ gr. sublimate). If cachectic ulceration be present, the action of mercury is likely to increase it, and ulcerations in the mouth especially may be caused by it: they are more irregular and less indurated than syphilitic ulcers.

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In exceptional cases, the secretion of sweat has been increased, it being of a clammy character and fetid odor: a general brown color of skin or the occurrence of rupia and ecthyma has been sometimes noted, but it is not true that eruptions really equivalent to syphilitic eruptions are produced by mercury.

The hair and nails are said to have fallen off under its use. The teeth are said to show the effect of the drug, especially when administered in infancy, by a deficiency in the enamel, most marked in the first molars (Hutchinson: *Medical Times*, ii., 1876, p. 242; Laycook, i., 1862, p. 450); but this is not yet an established fact.

With regard to the tissues of the *eye*, we have evidence that iritis and retinitis may be produced by the continued employment of mercury, but a more usual condition is conjunctivitis, which occurs with the ordinary symptoms, such as suffused redness and injection, smarting, burning, and some excoriation and purulent secretion.

Osseous System.—A form of periostitis occurs sometimes during a course of mercury, and it has been a question whether this is due to the remedy or to the malady (syphilis), for which it is commonly prescribed. Pereira thinks the latter supposition correct, but Graves states that he has seen periostitis occur in patients mercurialized for some other illness, and who had never contracted syphilis, and to this I can add my own testimony, having witnessed such an occurrence several times. The tibia, the bones of the forearm, the clavicle, sternum, and frontal bones are those more commonly affected, and the pains, intermittent at first, are increased by warmth, or by changes of temperature, though sometimes relieved by a low temperature. The articular ends of the bones are liable to be affected, and even caries may be produced.

Synergists.—Agents which fluidify the blood and secretions, such as alkalies, favor a similar action in mercury. Oxygen, dilute acids, and alkaline chlorides favor the transformation and absorption of metallic mercury, and hence assist its action. Bellini, however, concluded that these agents lessened the effect of mercurial chlorides and iodides by preventing the action of carbonated alkalies upon those salts in the intestine, and impairing the formation of double salts: magnesia he found distinctly adjuvant, it giving rise to a double chloride with mercury. Carbonate of soda has been found to increase its purgative effect (Hunt: *British and Foreign Review*, ii., 1852), and rhubarb, colocynth, jalap, or other purgatives are used to aid its action on the liver or intestine.

Alkaline iodides markedly increase the constitutional action of mercury—Wreden has especially shown this (*Central Zeitung*, 99, 1874, and *British Medical Journal*). A skin rubbed with *blue ointment*, and then after an interval, and after cleansing, rubbed with *iodine ointment*, becomes much inflamed, evidently from a chemical combination (biniodide of mercury). Milk, bromides, sulphites, and prussic acid, are also said to

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increase the effect of mercurial compounds (Bellini), and the good effects of mercurial treatment in syphilis are specially aided by the concurrent use of the sulphurous waters of Aix-la-Chapelle (*British Medical Journal*, i., 1874, p. 108).

ANTAGONISTS AND INCOMPATIBLES.—Sulphur, especially in the form of sulphuretted hydrogen, antagonizes the physiological action of mercurial compounds, whatever their therapeutical relations may be (*see* above). Chlorate of potash controls, to some extent, its salivating powers; *astringents*, such as alum and tannin, lessen fluxes, and tonics and stimulants oppose mercurial cachexia.

Finely divided iron, or zinc, or gold, acts as a mechanical antidote in cases of mercurial poisoning (Johnston: *American Journal*, April, 1863), but albumen is, perhaps, more efficient: the white of one egg is calculated to form an insoluble compound with 25 centigrammes (about 3½ gr.) of sublimate (Peschier).

Treatment of Mercurial Poisoning (Acute).—By an emetic of ipecacuanha, if necessary, the poison should be as far as possible removed, and then albuminous demulcent drinks freely administered. The white and yolks of raw eggs with milk are very suitable, or gluten may be prepared by washing flour in a muslin bag under a stream of water, or the flour itself may be given in a paste (Tanner). Opium may be required for the pain and purging, and, for the mouth-condition, gargles of alum or borax. For salivation sulphur has been strongly commended, and to promote elimination, when the acute symptoms have subsided, the iodide of potassium is to be advised. The symptoms of poisoning by corrosive sublimate are sometimes insidious, and after evacuating the stomach a principal indication is to sustain the strength. In a man under Dr. Mackey's observation, who had taken sublimate with suicidal intent and in large quantity, there were, at first, no symptoms, so that doubt was thrown on the history given with him when first brought to the Queen's Hospital. The stomach-pump was used, and for some days afterward he complained of nothing but slight abdominal pain and weakness. Milk and beef-tea were given—perhaps not in sufficient quantity—and stimulants were not ordered: he died in about a week, apparently more from asthenia than from irritant poisoning, but an inflammatory condition of the large intestine was found.

THERAPEUTICAL ACTION (EXTERNAL).—The destructive effect of mercurial compounds upon the lower forms of animal and vegetable life is extensively utilized in the treatment of *parasitic diseases.*

Phtheiriasis.—When pediculi infest the head or the clothing, ointments containing the red oxide, or the ammonio-chloride (white precipitate), will often suffice to cure, and have the advantage of being free from unpleasant color or odor: mercurial fumigations may sometimes be required for the body. For the pediculus pubis, blue ointment is com-

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monly prescribed, but it is not a pleasant application, and I have seen it produce much irritation. As in all cases when the hair is affected, destruction of the eggs or "nits," which are closely attached to the hair, is important for cure, and, for this purpose, weak lotions of sublimate are good (2 to 3 gr. to 1 pint water), or strong lotions of vinegar, followed by the use of a dusting powder or ointment containing calomel or white precipitate.

Tinea Tonsurans—Pityriasis—Favus.—The parasitic growths upon which these unsightly maladies depend are destroyed by lotions containing 1 or 2 gr. of corrosive sublimate in the ounce, which should be applied once or twice daily after cleansing: ointments containing the same, or the ammonio-chloride, are also useful. Their curative effect, like that of all similar remedies, is dependent somewhat on the state of the general health in ringworm of the scalp, and in favus, but in ordinary ringworm of the body (tinea circinata), and in pityriasis versicolor, a few applications will suffice for cure.

Dr. Alder Smith has recommended the oleates of mercury as having more penetrating power, and records their proving curative in chronic and obstinate cases not amenable to lotions, blisters, etc.: for children under eight he uses a strength of 5 per cent., and, for others who can bear it, 10 per cent., mixed with acetic ether, 1 part to 7; after cutting the hair close, thorough washing, and drying, this is rubbed into the whole scalp regularly night and morning, a cap or turban being worn to keep any of the preparation off the face: it is important that the head should not be washed more than once a fortnight. Mercurial remedies should not be used too concentrated, or over too large a surface, for fear of producing severe constitutional effects; and it is well to remember that blistering increases the absorptive power of the skin (*New York Medical Journal*, July, 1858). Under the heading of "absorption" we have mentioned cases in which death followed inunction of the scalp for ringworm, and would refer again to one in which a single painting with a vesicating solution of sublimate (gr. x. ad ℥ i.), caused salivation and death from mercurial poisoning (*British Medical Journal*, 1871). I have myself seen a case in which death resulted from the local use of a strong sublimate ointment, and more than one case in which serious symptoms resulted.

Other Skin Diseases.—In many non-parasitic forms of skin disease, mercurials are useful locally; sometimes by a "resolvent" action or quickening of the functions of the absorbents; sometimes by stimulating the epithelial and other tissues also; sometimes by exciting irritation of "substitutive character;" and in some cases by a powerful caustic effect. In syphilitic affections they exert a "specific" power, and in many cases their local action is supplemented by a varying amount of general action consequent on absorption. The late Mr. Startin, perhaps an empirical but certainly a successful practitioner in his specialty, and Mr. Naylor,

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who followed him, were accustomed to introduce mercury in some form into the treatment of almost all their cases; and if we do not use it so much, it is only that we have become more cautious than our predecessors as to doing harm by remedies.

M. Gubler has specially drawn attention to the cure sometimes obtained by mercurial treatment in very chronic skin-inflammation, such as psoriasis and eczema, and observes that it is a last resource not to be neglected, even if it be not easy to explain its action.

Eczema—Herpes.—In the acute inflammatory stages of eczema mercurials are usually unsuitable as being irritant, but Dr. Spender speaks highly of the use of lotio hydrarg. nigra in eczema rubrum: he adds glycerin, and applies it fresh three times in twenty-four hours, without oiled silk (*British Medical Journal*, i., 1878, p. 286). In subacute and chronic stages, with thickening from infiltration of the cellular tissue, moderate crusting, scaling, and dryness of skin, mercurial ointments are very serviceable; that of the red oxide often irritates, even at this stage, and that of the ammonio-chloride, diluted 1 in 4 or 8, is more generally suitable: Niemeyer specially commends it for chronic eczematous patches on the face. When there is more than average secretion or irritation, better results are obtained by a combination with equal parts of lead, or of zinc ointment, and a formula much used for eczema capitis at the Skin Hospital is the following: ℞. Plumbi acet. gr. x.; zinci oxidi, hydrarg. subchlor., ung. hydrarg. nitrat., āā gr. xx.; olei palmæ purif. fl. ʒ ss.; adipis recentis ʒ ss., misce: such ointments are useful in the chronic general eczema of childhood especially.

For eczema mammæ, which is often very obstinate, Hebra uses sublimate-lotions (1 in 120), but they require great care if any lactation is continued. For eczema of the genitals, Devergie recommended a very much weaker solution of the same; Guéneau de Mussy prefers calomel (15 gr. to ½ oz. of lard). For eczema about the hands, and especially for "cracks" about the fingers and nails, an oleate of 5 per cent. strength is said to be very efficacious (*Practitioner*, vol. x.). I have found an ointment of hydrarg. am. chlor. gr. v. to ʒ j. very useful for eczema capitis et aurium after thorough removal of the crusts, also for all cases of chronic eczema. In (non-parasitic) sycosis, mercurial ointments combined with sulphur give the best results. In herpes preputialis, calomel is a useful dusting powder.

Erythema—Ephelides (*Freckles*).—Many cosmetic waters owe their efficacy to a minute proportion of sublimate, or to an albuminate of mercury. M. Hardy's formula for the treatment of freckles contains lead acetate and zinc sulphate of each 40 gr., sublimate 8 gr., with alcohol 2 oz., and distilled water 4 oz.; it acts by slightly irritating the epidermis, so that this exfoliates quickly. For a more decided effect Hebra uses a stronger solution (about 4 gr. to 1 oz.), applying it for four hours till the

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skin grows red, or even is blistered, and then under soothing applications it peels off, leaving a new surface. For ordinary erythema of the face, a lotion containing 1 to 2 gr. in 4 oz. of almond mixture, with or without bismuth or zinc oxide, and spirits of wine, is very useful.

Acne.—The last formula is suitable for many cases of acne when sulphur would not be well borne; but the pustules of this disorder may often be aborted with still more satisfactory results by means of the acid nitrate of mercury. The apex of the pustules should be lightly touched with this, on a glass brush, or a match point, and the drop of liquid should be soon removed by blotting paper or sponge: some temporary irritation may be expected.

Psoriasis.—The application just described (of acid nitrate) has been recommended also for chronic patches of psoriasis, and especially for such as occur along the forehead at the roots of the hair, but it should be used with great caution. The ointments of white and of red precipitate have a certain value for psoriasis of the face, or scalp, or hands, because they have no unpleasant color or smell, but they are seldom so efficacious as tarry preparations. The iodides, with iodide of potassium, are also recommended (Rochard, Lailler).

Prurigo—Chronic Lichen—Pruritus.—In all itching papular eruptions, hot dilute solutions of the perchloride are likely to give relief. Trousseau recommends a strength of 12 gr. to the pint, and justly lays stress upon the importance of its being used hot.

In *prurigo* the ointment of ammoniated mercury either alone, or combined with hydrocyanic acid, or with lead compounds, often gives relief, and *calomel ointment* is a good remedy for pruritus ani, and for pruritus of the scalp connected with chronic eczema or pityriasis.

Erysipelas—Eruption of Small-pox.—Evidence may be found both for and against the use of mercurial ointment (ung. hydrarg.) in these conditions (Stillé). The application cannot be depended on for the arrest of erysipelas, but it has some power to relieve the burning pain, and to lessen the chances of pitting in small-pox: it certainly can prevent the maturation of a vaccine vesicle. The late Dr. Hughes Bennett thought highly of this treatment, and Mr. J. F. Marson says that a mercurial plaster in use at the Children's Hospital, in Paris, answers well: it is a modification of the emplastrum Vigo c. mercurio, and contains 25 parts mercurial ointment with 10 of yellow wax and 6 of black pitch; it is most suitable for semi-confluent cases, where the patient can use a little care, for in severely confluent attacks the application would soon be rubbed off by the restless movements ("Reynolds' System," vol. i.). There is also some risk of salivation, and other forms of ointment answer equally well, so that, although I have tried mercurial preparations in such cases, I have latterly abandoned their use.

Inflamed Lymphatics—Adenitis, etc.—When the parotid, the testis,

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or the mammary gland is inflamed, gentle frictions with mercurial ointment, or applications of it on lint, are suitable: in chronic superficial glandular swellings resulting from inflammation, or especially from syphilis, and also to procure absorption of inflammatory products in an early stage before suppuration has occurred, the same treatment is useful. The 5 to 10 per cent. solution of the oleate painted on night and morning is excellent, and I have known it succeed quickly in some cases where ordinary blue ointment had failed. For inflammatory and congestive conditions of the *uterus*, but more particularly of the *ovaries*, a combination of mercurial and belladonna ointments in equal parts applied externally is sometimes useful. It has been recommended even in fibroid growths.

Serous Effusions—Pleurisy—Hydrocele.—I have not been able to satisfy myself of distinct benefit from mercurial frictions in pleuritic or pericardial effusions, though they have been considered useful by others: in *hydrocele* in children Kock uses an ointment of the cyanide (1 part in 4), rubbing a very small quantity into the scrotum daily for three to six weeks unless erythema supervene: in such cases I have sometimes successfully employed, as a paint, a 2 to 10 per cent. solution of the oleate.

Goître (*Cysto-Adenoma of the Thyroid Gland*).—In true goître, as distinguished from fibroid or purely cystic enlargements, an ointment of the red iodide of mercury succeeds, according to the large Indian experience of my colleague, Mr. Macnamara, better than any other remedy.[1] The strength he recommends is of 15 gr. to the ounce of cerate, more than this causing unnecessary pain and soreness. A thin coating of such an ointment should be smeared over the goître, which should then be exposed to the full rays of the sun, or at least to bright light: artificial heat is not so effective (Frodsham: *Lancet*, i., 1860). Within half an hour smarting and burning are felt, and in another hour a blister forms, which needs to be treated only in the usual way. The good effects of the red iodide continue long after this blister has healed, the tumor decreasing day by day for several weeks. One application of the ointment every two months is sufficient for the most extreme cases. Mr. Macnamara has often seen tumors which extended from the chin to the breasts disappear after two or three applications; from ordinary blisters he has never seen benefit in such cases, and the expensive iodine ointment was found to act very slowly, compared to the mercurial preparation: he has never seen salivation produced by the red iodide, though it is said to have occurred in some exceptional cases.

Splenic and Glandular Enlargements.—Mr. Macnamara has also found the ointment of red iodide of mercury useful in the treatment of

[1] The credit of this application has been variously ascribed to Major Holmes, Captain Cunningham, or Grant. Mr. Macnamara's experience is based on 23,000 cases.

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"spleen," meaning the chronic enlargement resulting from ague or malaria (ague cake): he gives at the same time "ague powders" (quinine). At Netley this ointment forms part of the accepted treatment for such cases, phosphates of iron, quinine, and strychnia being given internally (Murchison: *British Medical Journal*, i., 1867). Dr. Andrew reports advantage from the same ointment at St. Bartholomew's Hospital (*Lancet*, i., 1869). Of course, in the enlarged spleen, consequent on mechanical impediments to circulation, heart-disease, etc., or on blood-poisoning, as in typhoid, or on amyloid, or other structural degenerations, mercurial ointments are useless, and even in malarial enlargements harm may be done by them, because splenic disease seems to render the system peculiarly liable to salivation and other ill-effects of mercury. Sir Joseph Fayrer has observed serious results from its use in splenic cachexia, with tenderness of the organ and much debility (*Medical Times*, i., 1874). Mr. Macnamara, however, as above remarked, has never seen salivation from a judicious use of the iodide ointment, and in all chronic cases it ought to receive a fair trial.

The ointment is equally applicable in cases of strumous enlargement of lymphatic glands.

Inflamed Joints.—In any persistent articular inflammations, whether traumatic, gouty, or rheumatic, mercurial ointments or oleates are useful applied with friction two or three times daily. Mr. Scott (Bromley) earned a high reputation by his successful treatment of "white swelling," chronic synovitis, etc., with a mixture of mercurial ointment, camphor, soap, and cerate, applied on strips of lint firmly covered with plaster strapping. Although this method is useful I commonly prefer gentle friction with an ointment of the ammonio-chloride, beginning with a strength of 1 part of the officinal ointment to 4 of simple cerate, and using afterward 1 part in 8 two or three times daily. Under this simple treatment, with rest, I have known good results, which other remedies had failed to procure: thus, in one case of chronic inflammation of the wrist-joint, where able surgical and hydropathic treatment had been fairly tried, this ointment relieved more than any other means, and in several cases of chronic disease of knee-joint already condemned to amputation, the limb has been saved (though with stiffened joint) by this application.[1]

[1] Mr. Marshall introduced, for these and other cases, the use of direct compounds of mercurial salts with oleic acid, as being "more elegant, economical, and efficacious." He recommends the yellow oxide to be precipitated by caustic potash from a solution in nitric acid, and then dissolved in oleic acid according to definite proportions—5 or 10 per cent. or stronger; the weaker solutions are clear, pale, yellow liquids, the stronger are opaque and unctuous, and, being rather irritant, may cause pain. Mr. Marshall recommends 1 gr. of morphia to the drachm of ointment when much pain is present, as in pleuritis, and paints 10 to 30 drops over the affected part (Lancet, i., 1872). Morphia dissolves readily in oleic acid, and may thus be combined with the mercury.

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Ulcerations— Whitlow.—In chronic indolent or suppurating sores, even when non-specific, the "black or yellow" lotions containing the respective oxides are very good applications—the ointment of the red oxide is a valuable stimulant. Martin has strongly recommended blue ointment in *whitlow*, rubbing it in every hour, in intervals of poulticing. I have also used this treatment with some advantage, but the frictions need not be so frequent. Chronic indolent ulcers of the leg, whether syphilitic or not, often heal quickly with small doses of mercury, and lotions or ointment of the same, when applied to a similar condition, produce cicatrization.

Syphilitic Ulcerations and Eruptions.—It is in these forms of disease that the efficacy of mercurial lotions and ointments is the most marked. For *condylomata*, calomel with astringents is a good dusting powder, but the acid nitrate, lightly applied, is still more effective: one application will sometimes destroy the growths when nitric acid alone, and other caustics have failed (*Practitioner*, August, 1874). The acid nitrate is also the best agent to employ in the rare cases when it is desired to destroy a chancre by caustic in its early stages. As a dressing for hard chancre and for squamous and ulcerative forms of cutaneous syphilide, the "emplastrum mercuriale" (Prussian form) is much commended by Dr. Liveing. It contains metallic mercury (3 oz.), turpentine (1½ oz.), and lead plaster (12 oz.).

For generalized syphilitic eruptions, especially those of papular or scaly character, baths of corrosive sublimate have been recommended by Baumé, Trousseau, and others; but their proportion of ½ oz. to each bath I think too large: headache, drowsiness, and sometimes colic and diarrhœa, were produced, and the skin irritated by them. Baths containing only 10 to 15 gr. have been found very useful for syphilitic infants.

Epithelioma—Lupus.—Cases of epithelioma have been cured by repeated painting with the acid nitrate of mercury, the morbid growth being destroyed in layers (Gay: *British Medical Journal*, i., 1862); and this mode of treatment is applicable with due care in instances where operation is not desirable. It has been used to the *cervix uteri*, but has sometimes caused severe salivation, so that it has not been generally adopted: bromine is more suitable.

Extending patches of lupus are often controlled by the nitrate, but it is not so useful in the *erythematous*, as in the *ulcerative* and *discharging* forms: its application is very painful, and should not be repeated more than once or twice weekly, and should be followed by soothing remedies. In chronic torpid ulcerative conditions, M. Lailler recommends an ointment containing the red iodide with iodide of potassium (about 7 gr. of each in 3 oz.), it is useful but irritant: it may be applied stronger to non-ulcerative forms. Cinnabar is combined with arsenic in "Cosme's paste," which is very useful for superficial lupus patches about the face: three

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applications are usually made, for twenty-four hours each time (*v.* p. 45).

Diseases of Mucous Membrane—Syphilitic Throat, Tongue, etc.—In ulcerative conditions due to syphilis, gargles of "black-wash" or applications of calomel in substance are most useful: more active effects are, however, to be obtained from painting with dilute acid nitrate—1 part in 8 or in 16: 1 min. to 1 oz. of water is sufficient for a spray (Lyster: *Liverpool Hospital Reports*, 1870). Trousseau used cigarettes for these and for laryngeal affections. A gargle of bicyanide of mercury (½ gr. to 1 oz.) is most useful when black-wash and other preparations fail.

For syphilitic and other ulcerations of the *Schneiderian membrane*, an ointment of the gray oxide is preferred (ʒ ss. ad ʒ ss.): a powder containing cyanide of mercury and camphor may be cautiously used.

In *Ozæna*, injections of black or yellow mercurial lotion are of some service, with powders for insufflation, containing calomel, bismuth, and white sugar.

In *Chronic Angina*, good results have been obtained from the local use of the diluted acid nitrate of mercury (1 part to 6). It has relieved "nervous cough," and also, it is said, spasmodic asthma (*Bulletin de Thérapeutique*, xxiii., 1842)—this would be of reflex character.

For *Chronic Laryngitis and Eustachian Catarrh*, Dr. Nevins has written in favor of mercurial vapor: it may be obtained from cigarettes made with blotting-paper soaked in a solution of nitrate (Trousseau).

In *Strumous* and *Catarrhal Ophthalmia* a lotion of corrosive sublimate is one of the best remedies, especially in conjunction with the internal use of the same preparation, or of calomel: 1 or 2 gr. of the sublimate are to be dissolved in 6 oz. of water, and of this, 2 dr. with an equal part of hot water applied three times daily. Under this lotion the conjunctival redness is lessened, the corneal pustules and ulcerations of the lids heal, while the discharge, the lachrymation, photophobia, and irritability of the adjacent mucous membrane all diminish. In this affection is well seen the special power of mercury to check threatening suppuration and to heal ulceration.

In *Blepharitis*, when the sebaceous glands near the ciliæ become inflamed or obstructed, causing redness, crusting, and irritation, mercurial lotions, or ointments, applied at bedtime after due cleansing, are very serviceable. Calomel ointment is the mildest, that of the red oxide the most energetic (B. Carter), but that of the freshly precipitated yellow oxide, introduced by Pagenstecher, is now the most generally used (*Ophthalm. Review*, v. ii., 115). I have been well satisfied with the effect of white precipitate ointment diluted with three or four parts of lard, and Haltenhoff (Geneva) prefers this.

Hordeolum (or "stye") is often best treated by applications of the same three or four times daily.

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Phlyctenular Ophthalmia and *Keratitis* of scrofulous character have been cured by insufflations of calomel.

THERAPEUTICAL ACTION (INTERNAL).—A general effect may be obtained, as we have already seen, from local applications made in several ways—by inunction, by endermic painting, or hypodermic injection, as well as by suppository or fumigation. These methods, which will be more fully described afterward, are utilized for mercury more than for other drugs, yet the ordinary mode of administration is simpler, and with due attention to the mouth and the digestion, is more satisfactory when the conditions of the illness admit of it.

Inflammatory Diseases.—From the time that Robert Hamilton described his successful treatment of inflammation by calomel and opium ("Duncan's Commentaries," 1764) down to perhaps twenty or thirty years ago, mercury in some form was, in English practice at least, the almost universal remedy both for acute inflammations, and for their results, such as effusions, adhesions, and indurations. Trousseau described mercurials as "les antiphlogistiques les plus puissants"—more active, perhaps, than blood-letting—and Nothnagel remarks that at one time the name of any malady ending in "itis" seemed sufficient to indicate their use. Sir Thomas Watson, in the later editions of his classic lectures, quotes his own earlier opinion that "mercury is a very powerful agent in controlling inflammation, especially when acute and 'adhesive' in character, also in preventing exudation," but owns that this can be said no longer—"it requires much qualification" (5th Ed., 1871). This is perhaps the most important point in which modern experience and opinion would discredit the therapeutical power of mercury. It is not denied that full doses can act destructively on the blood and the tissues, though we have given some evidence against its aplastic energy (*v.* p. 194), but modern clinical experience affirms that it has not *great*, but comparatively *little* power over *acute* inflammatory disorders, that these often run a natural course toward recovery independent of mercurial, or other medicinal treatment, and that when it is pressed to a full effect convalescence is protracted by greater anæmia and debility. (The unquestioned good results recorded from the treatment of Hamilton, which led to its general adoption, have been plausibly attributed to the *opium* rather than to the *mercury*.) Sufficient account of the evils that followed was not made by our predecessors, who, knowing too little of the natural history of disease, attributed all bad sequelæ to *it* rather than to the medicines, and considered themselves successful if, when "the disease was subdued," life at least was saved.

We cannot, on the other hand, agree with the assertion that mercury is never useful but always injurious in inflammation. There is evidence of its advantage in certain conditions, though this evidence is not so consistent nor so general as of its value in syphilis. It will certainly remedy

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some of the *results* of inflammation, as chronic effusions in joints or lungs, and, as Dr. Stephenson remarks when narrating such cases, no number of instances in which the medicine has been abused, or even has failed, can contradict the cases in which it has conferred evident benefit (*Edinburgh Medical Journal*, 1871). Dr. Habershon allows its value in cases of retained secretion, dropsy, gastric disorder, as a purgative, and as anti-syphilitic, but objects to its use in all degenerations and passive congestions, in fevers and exhausted conditions, in diseases of mucous membrane, in rheumatism, and *all inflammations* of lung, brain, etc. (Pamphlet on Mercury, *British and Foreign Review*, ii., 1860). For my own part, I still hold it useful in many chronic inflammations, whether syphilitic or not, affecting mucous and parenchymatous tissues, and having a general tendency to suppuration and ulceration, but I am satisfied that it should never be pushed to salivation.

Meningitis, and Cerebral Disorders.—The principal difficulty in judging of the effects of mercury in meningitis, and of the relative value of recorded cases, lies in the uncertainty of diagnosis. Cases of cerebral congestion, in children especially, present at first symptoms very similar to those of simple meningitis, such as pain in the head, vomiting, injection of the eyes, excitement followed by semi-coma, pyrexia, and even convulsion. Many years ago I usually treated such cases with minute doses of perchloride or iodide of mercury, and, as I thought, with moderately good results, but further experience has not satisfied me on this point. Many surgeons prescribe it in traumatic cases, and believe it relieves the fulness of the cerebral vessels, and although Dr. Ramskill ("Reynolds' System"), Stromeyer, and some other authorities might be quoted as still commending mercurial influence in meningitis, the general tendency of modern opinion is decidedly against its value. In many recent text-books, in Dr. Bristowe's for instance, it is not even mentioned. When the malady follows on febrile or eruptive diseases, or spreads from caries—*e.g.*, in the ear-bones—mercury is not likely to relieve it, and in other idiopathic or at least non-tubercular cases, I think aconite, belladonna, and bromides are of more importance in the early stages, and nourishment and perhaps iodides in the later ones. In cases presumed tuberculous I use iodide of potassium, generally with cinchona. Dr. Copeman, when narrating several cases of apoplexy and cerebral disorder in illustration of the beneficial action of mercury, fully adopts the proposition that it cannot prevent inflammation, but may cause absorption of its results—effusions, adhesions, etc.: he strongly advises its use, therefore, in all inflammations of *vital* organs, after the acute stage is passed (*Medico-Chirurgical Review*, i., 1872). I have seen it of some service in such cases, but many remain quite unaffected by it.

Chronic Hydrocephalus.—Of this disease, Gölis recorded a large number of cures under ¼ to ½ gr. doses of calomel twice daily, and mercu-

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rial inunctions of the scalp, but his results were not confirmed by other observers. Sir T. Watson refers to two remarkable cases cured by a mixture of metallic mercury 10 gr., fresh squill 5 gr., and manna, taken three times daily for three weeks: it caused weakness, emaciation and diuresis, but not ptyalism. I have not myself seen any good result in this condition from mercury.

Pericarditis.—To treat this inflammation without mercury would, a generation ago, have been reckoned almost criminal, and men no less eminent than Graves and Stokes have left their emphatic testimony in its favor—the latter gave 20 gr. of calomel once or twice daily. Yet soon afterward, Markham and Walshe began to doubt its value, and Todd denied it wholly. Watson says, "I am obliged to recant my advice as to giving mercury in acute pericarditis" ("Lectures," 1871), and Hayden is almost alone among modern writers in still recommending calomel and antimony ("Diseases of Heart," 1876). Waters, Austin Flint, and Loomis have discarded mercurials, and Sibson, in his able monograph, does not even mention them ("Reynolds' System," vol. iv.). Dr. Garrod states that full mercurial treatment of the joint-affection in rheumatism will not prevent pericarditis, and it would seem, therefore, scarcely likely to arrest it after its commencement: further, as it is almost always connected with, or dependent upon, rheumatism, its treatment should naturally be conducted on the same principles, and as we do not now give mercury for the main disease, why should we do so for one of its local manifestations? I have myself carefully watched its effects several times, and although the bruit and other physical signs have varied during the attack, I have never been able to satisfy myself of a definite influence of the drug upon the malady; on the contrary, I have seen this prolonged to more than an ordinary duration, while the gums have been sore. In subacute or chronic cases, where effusion has occurred and is persistent, I have seen benefit from small doses of sublimate or gray powder and mercurial applications locally, but when the effusion is very large, the pulse feeble, and cardiac paralysis threatening, any excess of mercury must be carefully avoided (Nothnagel).

Endocarditis.—In rheumatic endocarditis, on account of the still more serious issues involved in exudation and adhesion, more advocates are to be found for the use of mercury in the hope, at least, of controlling such results. I cannot dogmatize on this question, but I place more confidence in opium and rest.

Pleuritis.—Fuller and Walshe may be named among modern advocates of mercurial treatment in pleurisy, but for the acute stage I cannot see its advantage, since aconite, salines, belladonna, or morphia, with suitable local applications, give usually all the good results that can be expected from medicines. When effusion has occurred, however, I believe that mercury may be of considerable service in stimulating the ab-

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sorbents; and in some cases, when hectic has set in and there have been signs of commencing pus-formation, small doses of corrosive sublimate have seemed to me advantageous. I have also noted benefit from this medicine in pleuritis occurring in puerperal women, and a similar observation is recorded by Nothnagel. In no case should it be pushed to the production of salivation or anæmia.

Peritonitis.—Velpeau was the great advocate for a thorough mercurial treatment of this inflammation, and by enormous doses of calomel used concurrently with inunctions, he expected so to alter the blood in a few hours as "to prevent its furnishing the elements of a severe inflammation." Trousseau adopted for some time a similar method, for which he substituted later that of Dr. Law, giving minute doses frequently. Without accepting Velpeau's theory, it may be said that mercurial treatment—or rather calomel with opium—has been less completely abandoned in this inflammation than in many others. Watson certainly says "he is doubtful if it has ever done good, while if it purge it must do harm," but I believe that small doses of calomel or of sublimate ($\frac{1}{100}$ to $\frac{1}{50}$ gr.) have conduced to the recovery of some of my cases of acute and "idiopathic" peritonitis. I have generally given them every one to three hours alternately with aconite, and used opium as required for relief of pain. In localized forms of peritonitis, occurring, for instance, after perforation, or from peri-typhlitis, opium is the most important remedy.

Pneumonia.—In the early stages of acute pneumonia, formerly treated by calomel and antimony, I cannot recommend mercurials, but the time for using them with advantage is when secondary fever arises, and there is reason to fear purulent degeneration. So far as I can judge, they have seemed to exert some power in preventing this, for certain cases of the kind have improved on commencing the use of sublimate, and others have relapsed on its omission. In pleuro-pneumonia, with copious effusion, the same remedy is still more clearly indicated, and in chronic interstitial pneumonia it sometimes has excellent effect. Sometimes a syphilitic or strumous deposit occurs in the lung, rendering it partially solid, and giving the physical signs of a pneumonia, and these deposits, especially when of the former nature, seem to "melt away" under the moderate action of mercury: but careful diagnosis of such cases is required, for in true tubercular deposit the drug is injurious. Graves speaks highly of mercury "in scrofulous inflammation of the lung."

Bronchitis.—In acute cases, with much congestion of mucous membrane and scanty expectoration, small doses of perchloride are often useful. In certain cases narrated by Thorowgood, blue pill with squill was given with apparent advantage, when there was "severe cough at night, pyrexia with loaded urine, dyspnœa, some lividity of lips, difficult scanty expectoration, with râles, and perhaps impaired resonance" (*Practitioner*, i., 1878): this treatment is more suitable for robust adults than for the

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aged. In catarrhal bronchitis passing into pneumonia, frictions of the chest with oleate of mercury are said to be useful.

Coryza.—In ordinary coryza, especially when there is much sneezing, I have often found small doses of gray powder cure more quickly than any other remedy. Catarrh affecting the Eustachian tube is also well treated in the same manner.

Diphtheria—Croup (*Laryngeal Diphtheria*).—Stillé, after giving many authorities in favor of the mercurial treatment of diphtheritic disease, says himself "that it appears urgent that the system should be brought under mercurial influence as speedily as possible," and following Albers, he recommends ½ gr. of calomel every hour, and a scruple of mercurial ointment to be rubbed at intervals into the thighs. Trousseau, finding that the direct application of calomel to external diphtheritic surfaces modified favorably their condition, recommended its use by insufflation, or by allowing it to mingle slowly with the saliva; this has not, however, given much result. Bretonneau used mercurials freely, but his mortality was great, and contributed to induce a general distrust of the treatment. West, however (Ed. 1859), still considered calomel useful for "counteracting the tendency to formation of false membrane and preventing lung-inflammation." I have been myself much disappointed with the action of calomel in these respects, but the red iodide and the cyanide of mercury, in doses of $\frac{1}{50}$ to $\frac{1}{30}$ gr. every two to four hours, have exerted a more favorable influence in some severe cases. It is very important to watch their action carefully, and not to induce salivation, for according to general experience "this promotes rather than checks the spread of exudation" (Mackenzie), and certainly, as a general rule, other remedies of a tonic or antiseptic character are often to be preferred to mercurials.

Tonsillitis, etc.—In ordinary tonsillitis, and even in suppuration about the fauces, I have seen much advantage from small doses of hydrarg. c. cretâ. In early stages of quinsy, in ulcerated sore throat, and even in the "putrid" form (cynanche maligna), ½ gr. given every two to four hours has induced rapid improvement. It does not exclude the use of aconite or belladonna if indicated by high temperature or much pain. In parotitis ("mumps"), also in glossitis, "cancrum oris," and cracks and ulcerations about the mouth and lips, the same treatment is very effective. For relaxed congested conditions of the faucial membrane the value of dilute solution of mercurial nitrate has been already indicated.

Scarlatina.—The small doses of hydrarg. c. cretâ just mentioned I have found equally useful in the severe specific sore throat of scarlatina, especially when the cervical glands and adjacent cellular tissue are inflamed and swollen, and when there is ulceration or even a tendency to gangrene.

Morbilli.—Half-grain or quarter-grain doses of gray powder given

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every four hours will also control the catarrhal symptoms of measles: when the conjunctivæ and mucous lining of the nose, mouth, and throat are inflamed, and even when ulceration is present, they render excellent service.

Variola.—When the eruption is passing into the pustular stage, and when secondary fever is setting in, I can recommend ½-gr. doses of hydrarg. c. cretâ every three to four hours, for a few days. Unless the gums show signs of tenderness, this treatment tends to check and limit suppuration, and consequently to lessen in some degree the chances of pitting. The local use of mercurial ointment has been already mentioned (*v.* p. 207).

Enteric Fever.—We need not here refer to the older method of treating this fever by repeated purgative doses of calomel (*v.* Stillé), a method not now advocated; but several eminent physicians abroad—Traube, Wunderlich, Liebermeister, and others—have recently recommended a "specific" treatment for the first nine days of this fever by calomel, giving 10 gr. in a single dose the first day, and 8 gr. (in divided doses) daily for three or four days afterward. They claim for these doses an antipyretic effect, and a power of lessening both the duration and the mortality of the disease (*Medical Times*, ii., 1876). I have not had experience of this treatment, nor, although foreign statistics show good results, has it made way in this country. An early moderate purgative dose is, however, often advisable, and Black has written to recommend one or two 5-gr. doses of calomel during the first week, as "antiseptic" (*Lancet*, i., 1875). Corrosive sublimate in minute quantities has also proved valuable in typhoid diarrhœa (*British Medical Journal*, i., 1874), and this is in accord with my experience, but with these exceptions mercury is not indicated in the treatment of this fever.

Puerperal Fever.—Traube has also revived mercurial treatment in some cases of this disease—not for the general blood-poisoning—but at the commencement, when phlegmonous inflammation is spreading from the uterus, and involving other parts, *e.g.*, the peritoneum or pleura. He considers that a rapid and energetic mercurializing by calomel and inunction gives the best results, and states that such cases bear large doses, and that improvement generally coincides with the first signs of salivation. Spiegelberg especially observed the good influence of corrosive sublimate in similar conditions—he gave ⅛ gr. at a time (Nothnagel). Concerning this treatment, I can only say that I have not had occasion to adopt it, aconite, opium, quinine, etc., seeming to be much more desirable remedies.

Erysipelas.—In many cases of phlegmonous erysipelas, especially when occurring in strumous subjects, I have found the internal administration of corrosive sublimate distinctly useful.

Syphilis.—In 1497 Gilinus first employed mercury in the treatment

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of the then epidemic of syphilis, borrowing his practice from that of the Arabians in skin diseases, and using only external applications, by friction, bath, or fumigation. Several serious accidents that occurred from the remedy as used by empirics contributed to discredit it, and in 1517 it was almost entirely superseded by guaiacum. Not long afterward, however, the internal administration of corrosive sublimate, red precipitate, and calomel became general, and by the time of Boerhaave was carried to such excess that mercurial treatment was not considered thorough and satisfactory till it secured the ejection of three or four pounds of saliva in twenty-four hours. But some protest against such abuse was not wanting, and between mercurialists and anti-mercurialists sprung up a controversy which has lasted to our own time. In the early part of this century a reaction of opinion against the extravagant use of the drug in syphilis became general—thanks mainly to Rose and Guthrie, Thomson and Abernethy—and it was proved that syphilis sometimes tended to spontaneous cure, and yielded to non-mercurial treatment. Later on, an important distinction was made out between the soft or non-infective, and the hard infective sore, and professional opinion pronounced strongly in favor of mercury for the latter, while allowing it unnecessary in the former, and in gonorrhœa. This was clearly evidenced in the report of the Admiralty Commissioners on the subject, which records the opinions of forty eminent practitioners (1864). Among others, Sir James Paget called mercury "a specific—if the patient could take it well; in favorable cases it would prevent secondary symptoms, and at least it would shorten their duration." Mr. Hutchinson speaks of it as a "true vital antidote, and if given early, as really stopping the development of symptoms, and absolutely curing the disease." While agreeing in the main with this conclusion, I do not discard wholly the use of mercury in soft chancre, for I find that small doses cause the sore to heal more quickly than any other medicine.

Constitutional syphilis is commonly divided into three stages, fairly well distinguished as primary, secondary, and tertiary, and the best period for giving the remedy has been much discussed. Some have maintained that its early exhibition only *defers* the appearance of secondaries, and it is better for these to appear and then to give mercury till they disappear; but the best authorities favor early commencement. Ricord gave mercury—generally the iodide—so soon as the hard chancre was distinctly diagnosed, and insisting on a year's continuance of treatment, was satisfied that he prevented secondary symptoms. Barallier supported the same conclusion after much experience among sailors. The majority of British surgeons follow this practice at present, and it seems to me the right one.

On the other hand, most are agreed that in tertiary stages of syphilis, mercury is not a desirable remedy, and Dr. Wilks finds a reason for this

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in the different processes which occur at different periods of the malady. In the primary and secondary periods, plastic lymph is being effused, but in later stages degeneration is going on; mercury causes absorption of the effused products, but its *further* action can only assist degeneration, induce cachexia, and be thus injurious (*Guy's Reports*, vol. ix.). As clinical evidence of this, if any were needed, reference might be made to the cases recorded by Mr. Hutchinson, where phagedænic ulceration in delicate subjects distinctly increased under the influence of mercury (*London Hospital Reports*, vol. ii.). Also, if any syphilitic sore be much inflamed, or if aggravated dyspepsia, anæmia, phthisis, or albuminuria is present, special treatment for these conditions must be instituted independently of mercury. Pregnancy has been, by some, considered a bar to due mercurial treatment, but, in my opinion, the danger of miscarriage in the mother, and of injury to the infant, are greater from syphilis than from mercury.

In any case, a moderate use of the drug must be the rule. It is true that Trousseau and Pidoux blame a relaxation of the old methods for what they consider the present gravity of the disorder; but the large majority of the best authorities, including Ricord, Sigmund, and Hutchinson, deprecate full mercurialization, and find the best effects from small doses continued for a long time. Sigmund states that of nearly 9,000 patients treated in the Vienna Hospital, 8,500 showed no sign of salivation, but were cured as permanently as those salivated (*Medico-Chirurgical Review*, July, 1858). Slight tenderness of the gums may be safely and properly produced as evidence of systemic influence, and a method, sometimes successful, is to give fractional doses ($\frac{1}{12}$ gr.) of calomel every hour; given in this manner, 3 gr. may suffice for the purpose (Law, Dublin). In all forms of *tertiary* syphilis, rupia, and deep ulcerations, especially of mucous membranes, tongue, and fauces, gummata, visceral syphilis, and most syphilitic nerve-affections, the great remedy is not mercury, but iodide of potassium, though in hereditary syphilis mercury is still to be preferred.

In *syphilitic iritis* and *retinitis*, the early and sufficient use of mercury is perhaps more clearly indicated than in any other inflammation, and they are the only conditions in which Ricord held even salivation justified. Watson has graphically described how effused lymph in the anterior chamber may be seen to "melt away," under the influence of the drug; but unfortunately, this is evident only in syphilitic cases. I often combine with its internal use, collyria of corrosive sublimate, 1 to 2 gr. in 6 oz. of water with opium, or an ointment of ammonio-chloride with belladonna for frictions round the orbit, with good success; but the same treatment cannot be depended upon in rheumatic or traumatic cases.

In *syphilitic laryngitis* also, mercury must be promptly and freely

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used, for in acute cases life is rapidly endangered by the disease. Syphilitic infants, as a rule, develop only a subacute form of this disease, which may be treated less actively by moderate frictions with very satisfactory result. (For *catarrhal* laryngitis, mercury is not indicated.)

Scrofula.—Not only in syphilitic, but also in scrofulous diseases, small doses of mercury are useful. I know that this is not so commonly recognized, but ½ or 1-gr. doses of hydrarg. c. cretâ twice daily will often be found of great advantage in purulent discharges from the eye, ear, etc., as also in chronic glandular swellings.

Hepatitis.—Annesley recommended in this inflammation, large doses of calomel to the production of salivation, which he looked upon as "derivative," and no doubt at one time, as Maclean observes, "faith in calomel may be said to have attained in India to the dignity of a dogma." He, himself, strongly objects to any systematic use of mercury, and suggests that if it has gained credit for preventing suppuration, this has been in cases which were really of "*peri-hepatitis*," and not likely to end in abscess; in a large experience he has never seen it arrest suppuration, and "disbelieves in any such power" ("Reynolds' System," vol. iii.). Morehead and Waring agree in this opinion, and Massy reports serious impairment of health after its free exhibition. These authors may be taken as representing the present state of general opinion, but I think they have been too strongly prejudiced against the remedy by its excessive use, or abuse, and that small continued doses, stopping short of any full physiological effect, may still be found of advantage in commencing hepatitis; occasionally, larger (purgative) doses act well. In chronic forms of liver inflammation, when the viscus is large and tender, mercury is also suitable, though if marked cachexia be present, or suppuration be fully developed, the drug is better avoided.

Cirrhosis.—Monneret has strongly recommended moderate doses of blue pill in cirrhosis with dropsy (*Archives Gén.*, September, 1851), stating that after the numerous stools and copious sweatings induced, effusions are often absorbed, without any ill-effects from salivation. Barallier corroborated this experience, and further reported a case, not far advanced, which was cured by this treatment (Dictionnaire). I have certainly had the best effects from mercury in cirrhotic dropsy, but have generally used purgative doses of blue pill, or calomel, followed by salines, and in the intervals of purgation have given nux vomica and other tonics. Under such treatment large abdominal effusions have passed away six times in one case, at different intervals, so that the patient was restored to comparative health for some time, and this without any mercurial ill-effects. The diagnosis was verified post-mortem, but I cannot say that I have seen the malady permanently cured by this or any other treatment.

Hepatic Congestion—Constipation.—In torpor, or subacute congestion of the liver, marked by coated tongue, yellowish countenance, head-

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ache, nausea, depression, light-colored stools, etc., a moderate mercurial purge, especially with a saline, will commonly relieve more quickly than any other medication (unless it be sometimes podophyllin), and no amount of experiment on animals can alter this clinical fact. The great experience and authority of Murchison quite corroborate this (*Lancet*, 1874), and Dr. Duckworth has lately drawn renewed attention to the good results of calomel in acute gastric catarrh and "biliousness" (*Practitioner*, July, 1876). In chronic cases of this kind it is, however, advisable not to resort frequently to this remedy, but to depend rather upon diet, hygiene, and saline or vegetable aperients, though small doses—$\frac{1}{50}$ to $\frac{1}{20}$ gr. of corrosive sublimate at bedtime—have a good effect. The use of metallic mercury as a purgative might be thought obsolete, but an instance of it has been recently recorded, where obstinate obstruction and vomiting were present: 1 oz. of quicksilver was given in two doses at half an hour's interval; it soon acted, and recovery followed (*Lancet*, i., 1874, p. 54). I have myself used it in two cases lately: one was that of a boy, aged eight, who had had obstruction for five days, and although under active and competent treatment, continued to get worse, with vomiting, pain and accumulation over ilio-cæcal valve, distension, etc. Surgical interference was desired by the parents, but in consultation it was agreed to try mercury first, and 1 oz. was given in the manner just described. It was readily taken, and some of it soon passed, but without producing a motion; the symptoms improved, and on the following morning we gave castor-oil, which acted well, and the child soon recovered. The whole of the quicksilver passed was collected and weighed and found to amount exactly to the ounce taken. In a second case, a girl, aged between five and six, the obstruction had lasted several days, and the vomiting and other symptoms were persistent in spite of croton oil, etc. I recommended, at first, treatment by opium, which was steadily continued for three days, but without benefit; castor-oil was then given but was rejected; we then gave 2 dr. of quicksilver, in five minutes afterward another 2 dr., and in half an hour a third and similar dose. It made its appearance from the rectum in about two hours, bringing wind but not much fecal matter; we followed up the mineral with castor-oil, which was retained and acted, and the child gradually got well.

Vomiting.—In some forms of obstinate vomiting, dependent upon disordered stomach, with hepatic congestion, 3 to 5 gr. of calomel in pill or powder, have a most beneficial effect. The dose should be followed after a few hours by a saline purge.

Diarrhœa (*Infantile*).—When the motions are green, curdled, watery, and offensive, small doses ($\frac{1}{4}$ gr.) of gray powder act very well, especially when combined with bismuth, and the same powders are useful when curdled milk is frequently rejected from the stomach. When there is a simple diarrhœa, with whitish stools, Dr. Stephenson thinks that rhubarb

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and soda should replace the mercurial, for fear the latter should depress the strength (*Edinburgh Medical Journal*, 1871), and certainly, if it be continued unwisely, it may do so by irritating the mucous membrane, etc., but I have never seen ill-effects from the minute doses above recommended. For infantile watery diarrhœa $\frac{1}{100}$ to $\frac{1}{50}$ gr. of corrosive sublimate after each motion acts well (with due care). I think this is now a common experience; I have acted upon it for twenty-five years. In the acute diarrhœa and colic of adults, one of the best methods of treatment is the use of a pill of calomel (3 gr.) with opium (1 gr. or $\frac{1}{2}$ gr.), followed, after three or four hours, by castor-oil or other laxatives.

Dysentery.—In acute dysentery, with violent pain, severe prostration and frequent muco-sanguineous stools, small doses of corrosive sublimate, given at short intervals, commonly relieve in a few hours, and almost in a "specific" manner—certainly better than any other remedy I have known. Sublimate is equally useful in the "white dysentery" of Ceylon and India. I have seen the best results from it when opium, lead, and other astringents had proved useless. I thus agree with Wood, who asserts that in this malady "no remedial influence is more effective than that of mercury," rather than with Maclean, who deprecates its use in all forms and stages. I can only suppose that the injurious effects traced by him and by others to calomel, etc., resulted from doses that were too large.

Cholera.—Dr. Maclean equally objects to any preparation of mercury in cholera, as "useless in collapse and dangerous when reviving" (*Lancet*, 1866), but although I am not myself an advocate for the calomel treatment, the results obtained by Dr. Ayre, of Hull, deserve attention. He gave $\frac{1}{4}$ to $\frac{1}{2}$ gr. calomel every ten minutes or every four hours, according to circumstances; it rarely salivated, but produced apparently good results in a majority of cases. Bloxam and some other observers have followed the same plan with advantage, and Niemeyer speaks well of calomel treatment. What is desired is to stimulate by this means a secretion of bile and to promote elimination, for we know that the reappearance of bile in choleraic stools is a favorable sign; besides this, large doses of calomel ($\frac{1}{2}$ dr.) have been said "to restore warmth" (*British and Foreign Review*, i., 1870). Köhler thinks that its good effects are owing to the disinfecting property of the drug when brought into contact with the contents of the intestines. Of fifty-six cases, some of which received 200 gr. in two days, twenty-one died, but the reporter seems to think the results favorable to the treatment by calomel (*Lancet*, i., 1874). The general experience of the profession has not, however, adopted it, and it is clearly not free from danger, for under certain conditions a quantity of the medicine may remain for a time unabsorbed, and afterward produce serious toxic effects.

Intestinal Worms.—Calomel is a very suitable vermifuge in cases of

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ascarides. Both the round and the thread worms are expelled under the influence of 2 to 5 gr., which may be given early in the morning and followed in a few hours by a purgative draught. It is usual to combine the dose with powdered jalap, but I have found the mercurial alone sufficient, and it is more readily taken. Dr. Stillé speaks well of the effect of a small portion of mercurial ointment placed in the rectum daily at bedtime, for destroying ascarides, also of the injection of ¼ to 1 gr. of corrosive sublimate dissolved in water, but I doubt the wisdom of this treatment.

PREPARATIONS AND DOSE.—*Hydrargyrum cum creta* (contains 1 part of the metal to 2 of prepared chalk, rubbed together until globules cease to be visible): dose, for children, ½ to 2 gr., less or more; for adults, 3 to 8 gr., or less. *Pilula hydrargyri* (contains 2 parts of the metal with 3 of confection of roses, and 1 of powdered liquorice root): dose, as a purgative, 3 to 10 gr.; for constitutional effects, 2 to 3 gr. three times daily—may be well combined with quinine. *Emplastrum hydrargyri* (made with mercury, olive-oil, sulphur, and lead plaster). *Emplastrum ammoniaci cum hydrargyro* (contains gum ammoniac in place of lead plaster, or, in other words, ammoniacum and mercury plaster). An emplastrum mercuriale of the Prussian pharmacy is much used by Hebra and others in the treatment of syphilides, acne, etc., and is made according to the following formula:—℞. Mercury ℥ iij., turpentine ℥ iss., lead plaster ℥ xij. *Unguentum hydrargyri* (contains 1 part of mercury, 1 of prepared lard, and a little suet): this preparation should be lead-colored; from ½ to 2 dr. may be rubbed into the arm-pit or inner side of the thigh at one or several frictions in the course of the day, according to the rapidity of the effect desired. A pleasanter compound than the officinal ointment may be prepared from the following formula of Magne Lehrens, of Toulouse: Mercury 1,000 grammes, oil of sweet almonds 20 grammes, balsam of Peru 20 grammes, lard 960 grammes. The metal disappears rapidly in the oil and balsam, and the result is a smooth pomade, blue, agreeable in odor, and easily kept. Mr. Marshall's formula for oleates, already mentioned, is designed to prevent some of the unpleasantness of the ordinary blue ointment, and the following form, used in the marine hospital of Toulon, is calculated to produce constitutional effects without salivation:—℞. Slaked lime gr. xxx., chloride of ammonium gr. viij., sulphur gr. xxx., mercurial ointment gr. clxxx. This ointment dries very readily, and is prescribed in double the ordinary quantity. *Hydrargyri oleas:* made 5 to 10 per cent. and upward (*v.* p. 209). *Unguentum hydrargyri compositum* (contains mercurial ointment, yellow wax, and olive-oil and camphor): this combines the medicinal properties of mercurial ointment and camphor, to which wax and oil are added to give a suitable consistence; it is used as a stimulant to swollen glands, and for chronic inflammation of joints, and represents "Scott's ointment." *Linimentum hy-*

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drargyri (contains equal parts of blue ointment, solution of ammonia, and camphor liniment): it should be a lead-colored cream; this readily produces salivation. *Suppositoria hydrargyri* (contain mercurial ointment, benzoated lard, white wax, and oil of theobroma): there are 5 gr. of blue ointment in each suppository.

Hydrargyri subchloridum: dose, as a purgative, for children, 2 to 3 gr.; for adults, 2 to 5 gr.; for constitutional effects ½ to 1 gr. or more, frequently repeated, or $\frac{1}{12}$ gr. may be given every hour (3 to 4 gr. in this manner sometimes produce mercurial action), or ¼ to ½ gr. or more may be given night and morning combined with a fractional quantity of opium. *Lotio hydrargyri nigra* (contains 3 gr. of calomel to the ounce of lime-water). *Pilula hydrargyri subchloridi composita—Plummer's pill* (contains calomel, sulphurated antimony, guaiac resin, and castor-oil): each 5 gr. of the pill mass contains 1 gr. of calomel and 1 gr. of sulphurated antimony; calomel should not be given with alkaline carbonates, as corrosive sublimate is liable to be formed. *Unguentum hydrargyri subchloridi* (6½ gr. of this ointment contain 1 gr. of calomel). *Hydrargyri perchloridum:* dose, $\frac{1}{20}$ to ¼ gr. in solution or in pill: but very much smaller doses are used. *Liquor hydrargyri perchloridi* (contains ½ gr. of perchloride and ½ gr. of ammonium chloride to each fluid ounce, or $\frac{1}{16}$ gr. of each to the drachm): dose, ½ to 2 dr., *i.e.*, $\frac{1}{32}$ to ⅛ gr., but I prefer smaller doses, as mentioned above. *Lotio hydrargyri flava* (contains 18 gr. of corrosive sublimate in 10 oz. of lime-water).

Hydrargyrum ammoniatum ("white precipitate"): not used internally. *Unguentum hydrargyri ammoniati:* 1 part of ammoniated mercury in 8 of ointment.

Hydrargyri iodidum viride: dose, ½ to 3 gr. *Hydrargyri iodidum rubrum:* dose, $\frac{1}{16}$ to ⅛ gr., or less or more. *Unguentum hydrargyri iodidi rubri:* 1 part in 28 of ointment.

Hydrargyri oxidum flavum: used in the preparation of the oleate of mercury. *Hydrargyri oxidum rubrum:* for external use. *Unguentum hydrargyri oxidi rubri* (contains red oxide of mercury, yellow wax, and oil of almonds): there is about 1 gr. of red oxide in 8 gr. of the ointment.

Hydrargyri nitratis liquor acidus: used externally. *Unguentum hydrargyri nitratis* (citrine ointment): 1 part in 15½.

Hydrargyri sulphuretum—"artificial cinnabar" (not officinal): not used internally. Its fumes are used in syphilitic skin diseases, as ecthyma; also in syphilitic sore throat by inhalation, 30 gr. being heated on an iron plate and placed under the patient, who should be wrapped in a blanket; or the vapor may be inhaled through a funnel. *Hydrargyri sulphas:* not given as a remedy, but used in the preparation of corrosive sublimate and calomel.

[PREPARATIONS, U. S. P.—*Hydrargyrum; Hydrargyrum cum creta*

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(mercury 3 parts, prepared chalk 5 parts); *Emplastrum hydrargyri; Pilulæ hydrargyri:* mercury 384 gr., confection of rose 576 gr., liquorice-root 92 gr.; make 384 pills; *Unguentum hydrargyri* (mercury 2 parts, lard, suet, each 1 part); *Hydrargyrum ammoniatum* (white precipitate); *Unguentum hydrargyri ammoniati:* ammoniated mercury 40 gr., ointment 1 troyounce; *Hydrargyri chloridum corrosivum; Hydrargyri chloridum mite* (calomel); *Hydrargyri cyanidum:* dose, $\frac{1}{16}$ to $\frac{1}{8}$ gr.; *Hydrargyri iodidum rubrum; Unguentum hydrargyri iodidi rubri:* red iodide of mercury 60 gr., ointment 420 gr.; *Hydrargyri iodidum viride* (protiodide); *Liquor hydrargyri nitratis; Unguentum hydrargyri nitratis* (citrine ointment); *Hydrargyri oxidum flavum; Unguentum hydrargyri oxidi flavi:* yellow oxide of mercury 60 gr., ointment 420 gr.; *Hydrargyri oxidum rubrum* (red precipitate); *Unguentum hydrargyri oxidi rubri:* red oxide of mercury 60 gr., ointment 420 gr.; *Hydrargyri sulphas flava* (Turpeth mineral); *Hydrargyri sulphuretum rubrum.*]

Inunction.—The patient should be prepared for a course of mercurial inunction by simple dieting and by warm baths: and during it should be clothed in flannel and avoid exposure. When making the frictions himself, he should rub thoroughly in his hand the prescribed quantity of ointment, and then slowly and forcibly anoint certain parts of the body in a definite order: it is usual to choose the axillæ and the groins, but practically it is better to avoid parts with abundant hair-follicles. According to the German method of Zeissl, the inner side of both upper arms is first treated, on the next night the inner side of the thighs, then of the forearms, then of the legs, afterward of the groin and of the back, so that an interval of several days is allowed between the friction of any one part, in order to avoid local soreness. The evening is the best time for the application, and warmth promotes its effect: the part should be kept covered during the night, and be cleansed on the following morning. When the patient is too ill, or for any reason is unable to apply the ointment himself, the attendant who uses it should protect his own hand with a leather or caoutchouc glove. In young children frictions are often made on the inner side of the soles of the feet, or a piece of ointment is simply placed on the inner side of a thin flannel binder. For adults, ½ dr. up to 2 dr. represents an average amount of mercurial ointment for daily use; but sometimes, as in peritonitis, 1 dr. has been ordered every hour: it is important that no rancid ointment be used, or severe irritation may be induced by it. This method of treatment has the advantage of saving the digestive tract from any direct irritation from the drug, and, according to Sir B. Brodie, "it cures better and injures the constitution less." This, however, scarcely holds true in view of the modern cautious administration of mercury, and the method of inunction is less often adopted than formerly, since it is, at the best, troublesome and uncleanly.

The *endermic* application of mercury is effected by dressing a blis-

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tered surface with blue ointment or sometimes with calomel. From the latter, purging has resulted, but, as a rule, the endermic method is employed for a local stimulating action on the absorbents, as in pleuritic, pericardial, or joint effusion, rather than to affect the general system.

Hypodermic Injection.—The best form for this purpose has been much discussed; Lewin, one of the first to recommend it, used 5 milligr. of corrosive sublimate, but this is too much. Dr. Walker gave $\frac{1}{10}$ gr. in 10 minims of water and glycerin, and obtained good results in secondary syphilis without serious drawback, but Stohr, Greenfield, and others have reported local irritation, abscess, and even gangrene without therapeutical advantage. Liégeois added a minute quantity of morphia, but Staub's solution of albuminate of mercury secured more general approval. It is prepared with two separate solutions, thus: Corrosive sublimate, 1.25 gr.; chloride of ammonium, 1.25 gr.; chloride of sodium, 4.15 gr.; distilled water, 60 gr.: dissolve and filter. The second solution is made with the white of an egg very thoroughly agitated with 60 grammes of distilled water and filtered; the two liquids are then intimately mixed, and directed to be kept from the air as much as possible. The solution should, in fact, be prepared fresh as required, for it will not keep. One gramme contains 1 milligr. of the salt, and the dose should be about 1 centigr. daily at two injections. M. Bouilhon has recommended a solution containing a double iodide of mercury and sodium (*Practitioner*, 1869), and Scarenzi and Recordi the injection of calomel suspended in gum (*Practitioner*, 1870).

Stern's injection is made with 2 parts of sublimate and 20 of salt to 1,000 of water, and this does not precipitate albumen, and is a good form (*Lancet*, i., 1871), but Mr. Cullingworth, after many experiments, obtained by far the best of results with a minimum of local irritation by a solution of bicyanide, using 2 gr. with $\frac{1}{2}$ oz. glycerin and 4 oz. of distilled water (10 min.=$\frac{1}{16}$ gr.)—$\frac{1}{2}$ gr. made the gums tender (*Lancet*, i., 1874). Duncan, of Edinburgh, reports good results from the same (*British Medical Journal*, ii., 1874).

The advantages of the hypodermic method are facility of dosage and rapidity of effect, cleanliness, and freedom from gastric irritation, yet the unpleasant results which have sometimes attended it have quite prevented its general adoption.

The *Mercurial Vapor Bath* is the best method of application for some cases especially of syphilitic cutaneous disease. In it calomel or sulphide of mercury is vaporized in conjunction with steam, and becomes deposited as finely divided powder on the body of the patient, as he is seated unclothed over the lamp. Care should be taken that the vapor be not inhaled, or profuse salivation may occur.

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LITHIUM, L,=7.

This metal has not been found native. It occurs in the mineral kingdom as an oxide, chloride, silicate, or fluoride with potassium and aluminium (the lepidolite or rose mica of Bohemia). Bunsen and Matthiessen isolated it by means of electricity (1855).

Supposed at one time to be found in minerals only, it was named λιθιος, stony, but it is now recognized not only in many mineral waters, but in seas and rivers, vines and many fruits, the ashes of plants, and in most of our vegetable food (Bence Jones).

CHARACTERS.—It is soft, silvery-white, and easily oxidizes: it floats upon water, and is the lightest known metal, the sp. gr. being 0.5936.

COMPOUNDS OF LITHIUM.

LITHIA—OXIDE OF LITHIUM, L_2O,=30.

CHARACTERS AND TESTS.—Occurs in white granules, forms salts with acids, and has a high power of saturation, 15 parts neutralizing as much acid as 41 of soda or 47 of potash. For uric acid it has a special affinity, and will abstract it from portions of gouty bone and cartilage placed in warm solutions of the drug (Garrod).

The most characteristic tests for lithium are the carmine red color it imparts to flame, and the two lines which it develops on the spectrum, viz., one bright red line at point 82 of the micrometer, and one pale yellow line at 94. Of substances which resemble it, potassium has its red line at 68, sodium its yellow line at 100, and strontium has an additional line of blue.

LITHIÆ CARBONAS—CARBONATE OF LITHIA, L_2CO_3,=74.

PREPARATION.—From sulphate or chloride of lithium by adding carbonate of ammonium.

CHARACTERS.—Occurs in white powder, or crystalline grains, having an alkaline taste and reaction: is insoluble in alcohol, but slightly soluble in water (1 part in 100, or about 4 gr. to the ounce): carbonic acid increases the solubility to 5 parts per 100.

LITHIÆ CITRAS—CITRATE OF LITHIA, $L_3C_6H_5O_7$,=210.

PREPARATION.—By dissolving the carbonate in citric acid, evaporating the liquid, and drying and pulverizing the residue.

CHARACTERS.—A white amorphous powder, anhydrous, deliquescing

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on exposure, entirely soluble in two and a half times its weight of water: it is somewhat unstable in composition, and requires to be carefully kept from the air.

Some other compounds of lithia are likely to be used, but are not officinal.

The *urate* is very soluble, more so than the urates of potash or soda.

The *benzoate*, which is prepared from the carbonate by adding benzoic acid to the hot solution (*Pharmaceutical Journal*, July, 1875), occurs in glistening, pearly scales, of soapy feel, acid reaction, and cool, sweetish taste: it is soluble in three and a half parts of cold water, and ten of alcohol—it is thus more soluble than the carbonate, while it is more stable than the citrate, and has the advantage of containing an acid itself valuable in the treatment of urinary deposits.

A *ferruginous benzoate* of lithia has been prepared by M. Tréhyon (*Progrès Médicale*, July 25, 1874) and is recommended both as a non-irritant form of benzoic acid, and as a tonic and preventive of the anæmia produced more or less by all alkalies.

The bromide may be prepared by direct combination, and obtained in transparent crystals which are deliquescent. It contains a large proportion of bromide (92 per cent.), while the analogous salt of potassium contains only 66, and of sodium 78 per cent. (S. Weir Mitchell: *American Quarterly Journal*, October, 1870). The salt is used for photographic purposes.

Absorption and Elimination.—Lithia salts are rapidly absorbed: thus, from the experiments of Dr. Bence Jones, it appears that if 3 gr. of the chloride be given to an animal on an empty stomach, it may be detected even in the cartilage of the hip-joint, and the aqueous humor of the eye in a quarter of an hour: 7 gr. having been given to a parturient woman eight hours before delivery, lithia was afterward detected in every part of the umbilical cord, and 20 gr. of the carbonate having been taken three and a half hours before an operation for cataract, ample traces of lithia were detected in the lens when removed: four days afterward, lithia could still be detected in the secretions, and was not wholly eliminated till the end of seven days ("Lectures," p. 16). It is excreted chiefly by the kidneys.

Physiological Action (Internal).—*Digestive System.*—Lithia salts act much like the alkalies upon the gastric secretions,—the carbonate especially is a direct antacid. Small doses are readily borne, but doses of 30 to 50 gr. of carbonate—such as were used by Charcot—give rise, after a few days, to cardialgia and dyspepsia (Note to French edition of Garrod on Gout). Rabuteau also states, that though he, at one time, recommended 15 to 30 gr. per diem, his later experience proved that dyspepsia and even vomiting were caused by these quantities. Climent records similar results in his own person ("Traitement de la Gravelle,

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etc.," Thèse, Paris, 1874), and although lithiated waters—*e.g.*, at Baden-Baden—at first improve appetite and digestion, they quickly give rise to sickness and diarrhœa if taken in excess (Althaus).

Circulatory System.—Carbonate of lithia increases the alkalinity of the blood more quickly than potash or soda compounds (Garrod). The same salt, given in large doses (80 gr.), rapidly diminishes the number of red blood-corpuscles, and induces anæmia, like the alkaline carbonates (Climent, op. cit.). A much less quantity than 80 gr. seems to exert a depressant effect on the heart in weakly subjects—lithia in this respect, again, resembling potash in its action—but it does not depress so much as that salt (Garrod). Several observers agree in the conclusion that bromide of lithium, a salt with especially sedative powers, exerts a less lowering effect upon the heart than bromide of potassium (Roubaud: *Archives Gén.*, i., 1875, Lévy, Thèse, *Gazette Médicale de Paris*, 1875, No. 27), but frogs and some warm-blooded animals may die under toxic doses of lithia, with cardiac arrest in diastole (Husemann, Hesse).

Nervous System.—Lithia is said to depress the general nerve-power, and a slight degree of tremor or twitching has been sometimes noticed under its continued use, but I am not aware of any serious effects of this kind.

Urinary System.—The quantity of urine is generally increased under lithia, but analyses are not uniform as regards solid urinary products. Thus, M. Lévy, using the bromide of lithia in gouty subjects, found the excretion of urea and uric acid rather lessened (*Gazette Médicale de Paris*, November 27, 1875). In healthy subjects, however, Moss found both liquid and solid constituents much increased (*American Journal*, April, 1861). Diuresis is usually a marked effect of lithia. One or two doses of 1 to 4 gr. may not produce it, but if continued they do so, and commonly render soluble any urate deposit. In some persons one bottle of lithia water (about 4 gr.) will cause copious secretion, but the effect varies somewhat, possibly according to the amount of acid in the system. Dr. Garrod found lithia more active in this respect than potash, 20 to 30 gr. of the former citrate equalling 2 to 3 dr. of the latter. Moss corroborated this (loc. cit.).

Benzoate of lithia seems to have special powers in this respect, for it is very soluble, and the benzoic acid, changing in the system into hippuric acid, combines with alkalies to form hippurates, which are more soluble and more readily eliminated than urates. The diuretic action of any salt of lithia is much increased by free dilution.

SYNERGISTS.—Lithia is akin to potash, soda, and alkaline earths generally, but the characters of some of its salts indicate a special chemical analogy with magnesia. Thus, the carbonate is decomposed by heat, requires 100 parts of water for solution, but is more soluble in presence of carbonic acid: the phosphate is insoluble, the chloride and nitrate are

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deliquescent; there is no alum or bisulphate of lithia. Agents promoting waste, such as mercury and the iodides, also favor the constitutional action of this and allied medicines.

ANTAGONISTS AND INCOMPATIBLES.—Acids, acidulous and metallic salts.

THERAPEUTICAL ACTION (EXTERNAL).—*Gouty Concretions—Stiff Joints.*—These may often be well treated by a lotion containing about 5 gr. of any soluble lithia salt in the ounce of rose-water, kept constantly applied on lint, covered with oiled silk. I have generally combined this application with the occasional local use of iodine and the internal giving of lithia, and have known the concretions and the stiffness to be removed. A pomade containing oleo-stearate of lithia has been recommended for friction in similar cases (Duquesnel). Lithia lotions are useful also if the skin be broken near gouty joints. Such sores do not readily heal, because the urate of soda permeates the connective tissue near them, and an alkaline salt neutralizes the acid and promotes healing.

THERAPEUTICAL ACTION (INTERNAL).—*Gout.*—The treatment of gout varies somewhat, according to the acuteness or otherwise of the attack. During acute gout, lithia is often useful as an adjuvant or an alternative to alkalies, colchicum, etc., but it is during the intervals, when the urine is loaded and the joints obscurely painful, that the habitual use of small quantities is most advantageous. According to Dr. Garrod it lessens the frequency of the attacks, diminishes uric acid deposits, sometimes causes the absorption of concretions, and even wholly removes the gouty dyscrasia. Reasoning from the power of lithia in warm solution to dissolve uric compounds out of gouty bone external to the body, he presumes that it can exert an analogous effect within the system, and favor the elimination of the *materies morbi* in the form of urate of lithia. Wagner found, after ample experience, that treatment by lithia shortened the duration of acute attacks, and prolonged the intervals of freedom: it relieved pain and promoted elimination by diuresis. He gave from ½ to 5-gr. doses of the carbonate in an aromatic bitter, continuing them during the interval between the attacks for many weeks (*Schmidt's Jahrb.*, i., 1875, p. 232). Stricker reports a case in which gouty concretions on the finger-joints disappeared in a few weeks under a course of lithia (quoted by Garrod). Ditterich, while estimating the remedy highly, would restrict its use to chronic forms of gout or chronic illness of any kind, if dependent upon excess of uric acid. He found that doses of 5 to 10 gr. were liable to induce dyspepsia, and recommended not more than 1½ gr. for a single dose, or 15 gr. in twenty-four hours: he generally observed relief in seven to fourteen days without drawback (*Schmidt's Jahrb.*, October, 1870). When acidity of stomach is present, the carbonate should be given, because it is a more direct antacid than the other salts; if, however, there is no marked gastric derangement, the neutral

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citrate is to be preferred. It is decomposed within the system, and eliminated as carbonate in the urine. The ferruginous benzoate of lithia is much recommended by Dalkiewicz in his essay ("Sur la Goutte," 1873), by Malley, and other French physicians (*Medical Record*, November, 1874).

The Baden-Baden waters, though very useful in gout and in gouty headache, concretions, etc., are said to increase the joint pains during their early use (Althaus). There is only one spring, the Murquelle at Baden-Baden, which is distinguished for a considerable quantity of lithia, viz., 0.4 gr. of the chloride of lithium in 16 oz. Next to the Murquelle is the Fettquelle, in the same place, with 0.23 gr. of chloride of lithium, and a spring in Elster, with 0.76 of carbonate of lithia (Braun, p. 479).

With the exception of Dr. Garrod's writings, there are but few English observations on the treatment of gout by lithia, though the remedy must be largely used. It does not always give the satisfactory results that have been claimed for it, and some practitioners are still sceptical as to its real value.

Uric Acid Gravel—Calculus.—When this occurs, independently of distinct gouty attacks, lithia salts, amply diluted, often act well, rendering the "gravel" soluble and the urine clear. According to the observations of G. de Mussy and others, the bromide of lithia exerts a high degree of solvent or lithontriptic power (Roubaud: *Archives Gén.*, 1875).

Lithiated injections into the bladder for direct solution of uric concretions were proposed by A. Ure and Aschenbrennen. The former observer ascertained that an oxaluric calculus placed in a 4-gr. warm solution of a lithia salt lost 5 gr. in weight in five hours, but his practical application of this knowledge to the treatment of calculus within the living bladder has not proved very satisfactory. The patient got some temporary relief from the lithiated injections, and they were presumed to have softened the calculus, but did not reduce its size. Lithotrity was performed, but ultimately the man died (*Lancet*, ii., 1860). Mr. Ure directs attention to the necessity of avoiding lithia when phosphate of soda is present in the urine, otherwise an insoluble triple phosphate is formed.

Gouty and other Neuroses.—In the forms of irritative or melancholic nerve-disorders which sometimes accompany the uric acid diathesis, and in some forms of hysteria, the bromide of lithia promises to be extremely useful. The observers already quoted agree in attributing to it a marked sedative effect on the sensory nerves, and upon the spinal cord, and reflex sensibility, without much depression of the circulation: its action, in short, is more that of bromine than of lithia.

Epilepsy.—In true epilepsy, bromide of lithia was used by M. Lévy and by Dr. Weir Mitchell. The latter physician found that it was determined to the skin much like other bromides, but it proved a better

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hypnotic, and in moderate doses of 10 to 20 gr., relieved or cured epilepsy after larger doses of other bromides had lost their effect (*American Quarterly Journal*, October, 1870).

Acute and Chronic Rheumatism.—I have used lithia salts in these disorders, but with indifferent result.

Croup and Diphtheria.—Foerster, of Dresden, has recommended inhalation of a vaporized solution of carbonate of lithia as a solvent of the false membranes in these diseases.

PREPARATIONS AND DOSE.—*Lithiæ carbonas:* dose, 3 to 6 gr. (B. P). German physicians recommend less than this. The diuretic effect is increased by free dilution, and the *liquor lithiæ effervescens*, B. P., which contains ½ gr. to the ounce, is a good form: dose, 5 to 10 oz. *Lithiæ citras:* dose, 5 to 10 gr. (B. P.). I recommend less than these doses. *Bromo-citrate of lithia* in an effervescent water, containing also potash and soda, is prepared by some London chemists (*Lancet*, i., 1874); also a "granular effervescent citrate," which is a convenient and portable form, and contains 4 or 5 gr. in each drachm. *Urate and benzoate of lithia:* dose, 1 to 4 gr. *Bromide of lithia* (as a nerve sedative): dose, 10 to 20 gr. *A lotion* should contain 4 or 5 gr. of any soluble salt in each ounce. *A vesical injection*, 20 or 60 gr. of a soluble lithia salt in 4 oz. of water.

[PREPARATIONS, U. S. P.—*Lithii carbonas, Lithii citras.*]

MAGNESIUM, Mg,=24.

This metal is not found native, but may be isolated by decomposing its chloride with potassium or sodium. In combination it is widely diffused, a carbonate occurring in magnesite and limestone rocks, a sulphate and chloride in sea-water, in many mineral waters, and in almost all spring-water: a silicate forms talc, meerschaum, etc., and is present in small quantity in all soils, whence it passes (mainly as a phosphate) into plants and animals.

CHARACTERS.—Magnesium is white, lustrous, hard, and very light (sp. gr. 1.74). It readily oxidizes, and when lighted burns with intense brilliancy.

COMPOUNDS OF MAGNESIUM.

MAGNESIUM OXIDE—MAGNESIA—MAGNESIA LEVIS—LIGHT MAGNESIA, MgO,=40.

The two oxides, identical in composition, differ in the arrangement of their molecules, and, consequently, in their weight.

PREPARATION.—By strongly heating the heavy and light carbonates

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respectively, until all carbonic acid is driven off: hence the name "calcined magnesia."

CHARACTERS.—Magnesia and light magnesia occur as white powders, almost tasteless: the heavier form is called simply "magnesia" and is smoother than "magnesia levis," and more readily miscible with water. A given weight of the light variety occupies three and a half times the bulk of the same weight of the condensed magnesia. (There is no advantage in retaining both in the Pharmacopœia.) Both forms are almost insoluble in water, but their solubility is increased by heat; they absorb water, and if kept long in it, may form a concrete mass of "hydrate." They are soluble in acids.

MAGNESIÆ CARBONAS—CARBONATE OF MAGNESIA—MAGNESIÆ CARBONAS LEVIS—LIGHT CARBONATE OF MAGNESIA, $3(MgCo_3)MgO\ 5H_2O$, =382.

PREPARATION.—By dissolving in boiling water and then mixing sulphate of magnesia, and carbonate of soda, evaporating, and then washing and drying the precipitate. To prepare the *light* variety, the first solution is effected in a *large* quantity of *cold* water, which is afterward boiled. The result of the decomposition is an oxycarbonate, which is hydrated, and sulphate of soda is removed by washing. Thus:

$$4MgSO_4 + 4Na_2CO_3 + 5H_2O = 3MgCO_3MgO5H_2O + 4Na_2SO_4 + CO_2.$$

CHARACTERS.—The carbonates are white powders, soluble in acids with effervescence. The light form appears under the microscope partly amorphous, with slender prisms intermixed. Their solubility in plain water is slight, but it is much increased by carbonic acid, which converts them into bicarbonates.

MAGNESIÆ SULPHAS—SULPHATE OF MAGNESIA—EPSOM SALTS, $MgSO_4 7H_2O$, =246.

PREPARATION.—By evaporating sea-water or saline springs—also from dolomite, by treating with sulphuric acid: soluble sulphate of magnesia is dissolved out and crystallized, insoluble lime sulphate is left.

CHARACTERS AND TESTS.—Occurs usually in small acicular opaque or whitish crystals, but may be obtained in large, transparent, rhombic prisms. The pure crystals are somewhat efflorescent; but if they contain chloride of magnesium they are moist or deliquescent. Iron is an occasional impurity, and gives a reddish tint to the solution.

The small acicular crystals resemble those of zinc sulphate, with which, indeed, they are isomorphous: they may be distinguished (1) by the taste, magnesia sulphate being bitter and nauseous, zinc sulphate astringent; (2) ammonium sulphide gives with magnesia no precipitate, but with zinc a

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white one of sulphide (ZnS); (3) caustic potash gives with magnesia a white precipitate insoluble in excess, with zinc, a white precipitate soluble in excess. The rhombic prisms resemble those of oxalic acid: the latter are markedly acid to the taste, and are colored a purplish brown by common ink; magnesia sulphate is not affected by it (except blackened where touched).

Absorption and Elimination.—Magnesia and its carbonates and neutral salts, such as the citrate and tartrate, are changed into chlorides in the stomach, and absorbed either wholly or in part according to the amount taken and the condition of the gastric fluids (Buchheim and others): not more than 15 gr. at a time is changed (Rabuteau); the unabsorbed portion passes on into the intestine, and under the influence of albuminous secretions, or of carbonic or other acids, especially in the large intestine, an additional amount becomes absorbed, and any residue passes unchanged with the fæces, or under certain circumstances accumulates in the bowel, and forms concretions. Absorption varies with the degree of acidity of the intestinal tract, and if this be not marked, lemonade or other acidulous drinks will be required to secure solution. We need scarcely say that absorption varies also with the nerve-condition (*v.* p. 237). Part of the absorbed magnesia appears in the urine as a triple phosphate.

The sulphate of magnesia, given in *small* doses, is wholly absorbed without producing definite physiological effects. Of large and purgative doses, part only is absorbed, and passes out by the urine or other emunctories. Part of the sulphuric acid of the sulphate is withdrawn by potash and soda salts met with in the bowel, and the magnesia is almost wholly excreted with the motions combined, more or less, with effete bile-products (Buchheim).

Physiological Action (Internal).—*Digestive System.*— Magnesia and its carbonate act as direct antacids and local sedatives; also, when given in powder, as mechanical absorbents. A dose of 30 gr. and upward, given to an adult under conditions favorable for absorption, produces, after eight or ten hours, moderate semi-solid motions, of less than normal odor. It has been stated that the effect of these preparations, though less quickly produced, lasts longer than that of stronger cathartics, and is often more copious, 1 dr. of magnesia causing more evacuation than 1 oz. of Glauber's salt (Trousseau)—also, that their effect increases with continuous use, so that bloody and mucous stools may occur after some time. On the other hand, if the drug accumulates in the intestine, mechanical obstruction may be caused by it, and concretions of ammonio-magnesian phosphate, mixed with mucus and débris of food, have sometimes formed when large quantities of magnesia or its carbonate in solid form have been taken; as much as 2 pints (Gubler) and "several pounds" (Brodie) of such concretions have been found in the colon, and Dr. G. de Mussy

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required a mallet and chisel to remove one from the rectum (*Medical Times*, ii., 1879).

Peritonitis and even perforation have followed from such obstruction, and I have myself seen one fatal case of the kind. The patient was an actor, accustomed to hurried, irregular meals, and to consuming large quantities of magnesia (for constipation), and on making a post-mortem examination the large intestine was found blocked up by magnesian concretions.

(When a moderate degree only of such a condition is suspected, full doses of vinegar deserve a trial.)

The citrate of magnesia acts as a mild, but efficient and somewhat quicker laxative, and being more soluble than the oxide or carbonate, is free from risk of concretion.

The sulphate, in small doses, acts as a gastric sedative, and if not sufficient to purge, often exerts a diuretic effect, especially if the skin be kept cool: 1 to 2 dr. freely diluted, and taken on an empty stomach, will usually produce several watery stools without colic but with some distension, rumbling, and sense of chilliness. The bitter, unpleasant taste, if uncorrected by carminatives, may induce nausea and debility, but these symptoms subside when the purgative effect commences. The pulse and temperature are lowered by the action, and some malaise may be felt from it; more or less subsequent constipation will also be noticed: the biliary secretion is not increased by it (Rutherford).

Much larger quantities (1 to 2 oz.) are sometimes taken by ignorant or careless persons, and if given to the weakly may cause serious depression, amounting to syncope, with or without severe purging: Christison refers to a fatal issue from a dose of 2 oz. On the other hand, it has been stated that minute quantities (1½ gr.), given by hypodermic injection, will induce characteristic serous motions (Luton: *Gazette Hebdom.*, 1874), but Caville could not verify this result on dogs, and Professor Gubler's trials resulted only in local abscess, so that we cannot depend on Luton's method.

It is, however, ascertained that when even large doses are injected into the veins, no purgation is caused (Moreau, Rabuteau), but rather constipation, and this fact bears upon an explanation of the medicine's action. [Cl. Bernard has stated that the intravenous injection of soda sulphate causes as much purging as its internal administration (Leçons, p. 85), but later observers are very clear as to the contrary.]

Theory of Action.—Poiseuille, and also Liebig, taught that the purgative action of salines when taken by the mouth was due to osmosis of serum *from* the vessels *into* the intestine, and in support of this view Moreau found that on including a portion of intestine (of an animal) between two ligatures, and injecting into it a drachm of Epsom salts dissolved in a little water, afterward returning the intestine to the ab-

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dominal cavity, a large quantity of fluid was poured into the ligatured portion within twenty-four hours (*Archives Gén.*, 1872). Vulpian corroborated these observations, but noted also intestinal catarrh, which others have not done (*Gazette Hebdom.*, May, 1873). Dr. Lauder Brunton has recorded, in an interesting paper, results similar to those of Moreau (*Practitioner*, vol. xii.). By means of ligatures he made three loops of intestine, and injecting into the middle one a measured quantity of water with a few grains of magnesiæ sulphas, and into the others the same amount of water only, found, after a few hours, that the middle one contained treble the quantity of fluid injected, while the others were empty. He experimented also with *concentrated* solutions passed into the middle loop, always with similar result, and suggests that it is produced by a *direct stimulation* of the intestinal mucous membrane. Rutherford and Vignal also consider the drug a pure stimulant to the same membrane; this, however, was not found congested in the experiments, and although Brunton thinks that the structure of the intestine renders the osmotic theory unlikely, I believe that it best explains the facts with which we are acquainted.

For instance, constipation occurs if sulphate of magnesia be injected into the veins, and it may be presumed that an osmotic current is then directed *from* the bowel *to* the blood, and thus the intestinal contents are deprived of ordinary moisture: also constipation results from taking (by the mouth) *small* doses of 5 to 10 gr., and these may be supposed to become absorbed *quickly* into the circulation, and to act as if directly injected into it (as just described): again the purgative effect of full doses (draining off fluid) is followed by constipation. (Rabuteau explains this last fact by supposing a small portion at first absorbed, and producing its physical (endosmotic) effect several hours afterward, but I think it more probably a natural reaction connected with loss of fluid and empty condition of intestine.)

Some eminent writers, chiefly German, have offered other explanations which require a brief notice. Radziejewski observed, in experiments on animals, that the fæces were quite liquid when passing from the small to the large intestine, and argued that saline purgatives simply *hurried them through* in this liquid state, and that the larger quantity of fluid in stools procured by purgatives could not come from the blood, or even the glands, because on analysis the proportion of albumen in them was found too little for such a source (Reichert's *Archiv*, 1870, 39, 77). Thiry, experimenting with the peculiar form of intestinal fistula devised by himself, and formed by a separated portion of bowel communicating with the external surface of the abdomen, found that although local irritation would excite secretion in it, saline purgatives, such as soda sulphate, would not do so, and concluded, with Radziejewski, that they simply *increased peristalsis*. Buchheim taught that besides this, on account of

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their low diffusion-power, they did not readily pass through the intestinal membrane, but, remaining in the canal, retained the water in which they were given, and also much of the natural watery secretion from liver, pancreas, and glands (a very large quantity, according to Kühne), and so carried from the intestine a large quantity of fluid without necessarily drawing it from the blood by endosmosis, or from the glands by stimulation. These reasonings, although ingenious, seem to me answered or qualified by the later experiments of Moreau and of Brunton. Thiry's fistula disarranges normal structure too much to furnish a strong basis for hypothesis, while Legros and Onimus have satisfied us that peristalsis *per se* is but little increased by sulphate of magnesia (*Journal d'Anat.*, Robin, 1869). The purgative action of saline is not, however, a mere physical occurrence, the same in any membrane, living or dead; it implies integrity of nerve-supply, for Moreau found that no endosmosis occurred in an intestinal loop if he divided its connecting nerves.

Urinary System.—Magnesia has sometimes caused the solution of uric acid deposits when alkalies have failed to do so, and Mr. Brande pointed out that it could render the urine alkaline, more permanently, if more slowly, than potash or soda. Thus, 2 dr. of soda gave a maximum of alkalinity in a quarter of an hour, 1 dr. of magnesia only at the end of six hours, and ½ dr. in twelve hours ("Philos. Trans.," 1810). A deposit of triple phosphate occurred, but since earthy salts can be passed in only limited quantities in the urine (Neubauer and others), it is of interest to know precisely how magnesia rendered the secretion alkaline. Caulet concluded from recent researches that both it and lime do so only *indirectly* through the digestive organs—*i.e.*, they neutralize a part of the acid of the gastric juice, and consequently more soda is excreted with the urine, and becomes the direct agent in determining its alkalinity. In support of this, he finds on analysis no increase in the amount of earthy salts in the urine (rendered alkaline under administration of magnesia), but marked excess of soda (*Bulletin de Thérapeutique*, 1875). In further support of this observation, we have the fact that during normal digestion, when the acid of gastric juice is being neutralized and withdrawn from the system, acidity of urine becomes less, and in some stomach-disorders is even replaced by alkalinity (Roberts, Jones).

An observation from comparative anatomy is also of interest. If much lime or magnesia were to be excreted by the urine in conjunction with uric and phosphoric acid, the insoluble salts formed would render the secretion *solid*, or nearly so, as it is in birds and reptiles. Such a secretion would not readily pass through the narrow urinary channels of the human race, and therefore *alkaline earths* pass out rather through the bowel, while in herbivora, the urine of which must be fluid and yet contain much earthy salt, the *acids* are excreted by the bowel (Caulet).

Glandular System.—Some observers have attributed to magnesia an

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alterative action, and Grange, Bouchardat, and others state that its habitual use, as in drinking water, will cause goitre. Some support is given to this idea by the fact that enlargement of the thyroid gland in mice has followed after mixing magnesia with their food (Gubler), but on the other hand, many waters from goitrous districts have been analyzed without finding in them a trace of magnesia (*Medico-Chirurgical Review*, i., 1862, p. 512).

Toxic Action.—Jolyet and Cahours report magnesian sulphate to be the most toxic of neutral purgative salts, 30 to 90 gr. having caused sudden death in dogs, when injected into the veins. Vulpian noted abolition of voluntary and reflex movements in a frog poisoned by the salt, and its effect has been compared to that of curare, but this comparison requires further support before it can be accepted (*Archives de Physiol.*, Fév., 1869).

Synergists.—Absorbent substances, such as charcoal and manganese, aid the mechanical effect of magnesia in powder. Its purgative effects are aided by acids, by the sulphate and citrate of magnesia, and other neutral salts. It is usual to combine the sulphate and carbonate in a mixture, but unless care be exercised they are liable to form lumps which are not readily soluble. The analogues of sulphate of magnesia are the sulphates, phosphates, tartrates, sulphovinates of potash and soda, and the chlorides of sodium and magnesium. Water, cold, and refrigerants generally are other adjuvants of its action. Dr. Laycock found quinine aid the purgative effect of magnesia sulphate, 1 gr. of quinine with only 1 scruple of the salt, given every three or four hours, acting as well as much larger doses given without the tonic: he supposed this to depend upon improvement of nerve-power (*Medical Times*, i., 1863, p. 54).

Antagonists and Incompatibles.—Acids given with magnesia destroy its absorbent powers, though increasing purgation; on the other hand, alkalies antagonize its purgative effects by neutralizing gastric acidity. Alcohol, aromatics, and opium lessen its anti-febrile and depletory effects. With regard to opium, Buchheim and Wagner observed that if it be brought in contact with mucous membrane before the saline, no increased flow of liquid occurs, but liquid is absorbed from the membrane: they concluded that opium favored the absorption of the salt, but we hold rather that it acted like Moreau's section of the nerve-supply—narcotizing the terminals, dulling the sense of irritation, and so preventing a flow of liquid *toward* the part—while absorption *from* it went on as usual (Gubler).

Magnesia as an Antidote to Arsenic, Cobalt, and Phosphorus.—Magnesia forms a rather insoluble salt with arsenious acid, and is ordered in the German Pharmacopœia as part of the officinal "antidotum arsenici."[1]

[1] Seven parts of magnesia mixed with 120 parts of water are to be kept in one bottle, and 60 parts of liquor ferri persulphatis, with 120 of water, in another bottle. The

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Schroff proved magnesia to possess antidotal powers in cases of poisoning by arsenic and cobalt, if given early (*Medico-Chirurgical Review*, i., 1859). Sugar and magnesia mixed together have been found useful (*Lancet*, ii., 1873, p. 157). Orfila proposed it as an antidote to phosphorus, and there is some but not conclusive evidence in its favor (*Medico-Chirurgical Review*, i., 1857).

THERAPEUTICAL ACTION (EXTERNAL).—Magnesia being smooth, light, non-irritant, and antacid, makes a good absorbent dusting powder. It has been used for erythema, erysipelas, and similar inflammatory conditions of the skin, and also for atonic ulcers, exposed surfaces, and inflamed wounds.

THERAPEUTICAL ACTION (INTERNAL).—*Dyspepsia.*—In acidity, pyrosis, and allied symptoms of irritative dyspepsia, such as heartburn, flatulence, colic, or constipation, magnesia and its carbonate are very useful, and their efficacy may be increased by the addition of bismuth or of carminatives: such symptoms are often brought on by food containing too much fat, and this point should be attended to. Headache, accompanied with nausea and mental depression, often occurs in the conditions described, and may be relieved by magnesia. When vomiting is a troublesome symptom in the dyspepsia either of children or adults, and in the vomiting of pregnancy, magnesia often acts well. An effervescent solution of the carbonate or citrate is a good form, but 5 to 10-gr. doses of the sulphate will sometimes act better. I have known this succeed in the vomiting of albuminuria, and in cases where hepatic derangement was more marked than acidity.

Acidity and Diarrhœa of Children.—The mild antacid and laxative action of magnesia, and its slight taste, render it a very suitable remedy for the acidity of stomach which so readily occurs in children; it is valuable both when constipation is present, and when unwholesome food has caused irritative diarrhœa (marked by red furred tongue, and greenish, sour, and liquid motions): 2 to 10 gr. of the carbonate may be given thrice daily, its antacid action only being desired, and its purgative effect avoided, unless with the first dose. On several occasions I have known 4 gr. severely purge an infant at the breast. When the attack is clearly traceable to unsuitable food, "Gregory's powder," containing rhubarb and ginger, with the magnesia, is a popular and very useful combination.

Constipation.—In the constipation of delicate persons, especially of pregnant women, also of those subject to gout or rheumatism, hemorrhoids, or other rectal affections, magnesia is a valuable mild laxative; if required frequently, it should be taken in solution (fluid magnesia), and with lemon-juice, if the system be free from acidity. The citrate or

two preparations are mixed only at the time of their being required: hydrated peroxide of iron is precipitated, and sulphate of magnesia remains in solution—4 to 6 dr. of this should be given every quarter of an hour in warm water (Bins).

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the sulphate are useful aperients at the commencement of a febrile attack of almost any kind, their action being rapid and more or less depletory; the former may be given effervescing in mild cases, but when a full and decided effect is desired, 1 or 2 dr. or more of the sulphate should be used; sometimes it is given in lemonade or acid infusion of roses, but general experience has proved that it acts best with tincture and infusion of senna. In habitual constipation ½ to 1 dr. given in a glass of lemonade or aromatic water, in the early morning, will often answer every purpose. Dr. Fleming found the addition of small quantities of atropia advantageous (*British Medical Journal*, ii., 1865): it is more usual now, and I believe better, to make use of the magnesian salts in *combination* with others, as they are found in many natural mineral waters, such as Seidlitz, Pullna, Friedrichshall, or Hunyadi Janos, half a glass or a glass of such waters being ordered with warm water in the early morning. To obviate constipation and headache during the use of astringent tonics, moderate doses of the sulphate may be usefully added to medicines containing sulphate of quinine, iron, acids, etc.

Obstruction.—In cases of intestinal obstruction dependent upon hardened fæces, full doses of the sulphate, freely diluted and given every four hours, often succeed well; sometimes the action may be favorably assisted by belladonna.

Plumbism.—In cases of colic and constipation dependent upon lead-poisoning, sulphate of magnesia is a valuable agent; it should be used in conjunction with iodide of potassium, and Dr. Lauder Brunton has well shown that if the latter remedy removes from the tissues the metal in soluble combination, yet it is readily reabsorbed unless the bowels be freely and regularly moved (*Practitioner*, vol. xii.): ½-oz. doses may be required. Dr. Copland and others used the sulphate with sulphuric acid before the special value of the iodide was known.

Jaundice.—Although the sulphate has no specific cholagogue action, it is a very suitable aperient in cases of jaundice. Dr. Budd recommends it in combination with the carbonate and aromatics, but I generally prefer one of the mineral waters before mentioned.

Diarrhœa.—In intestinal irritation and diarrhœa dependent upon unwholesome food, and especially stone-fruit, sulphate of magnesia is a good evacuant, because it produces so little irritation. In cases of severe dysenteric diarrhœa from this cause I have often given drachm doses at intervals of six hours, for three or four doses, with the best results.

Enteritis—Dysentery.—Dr. H. Wood speaks of the sulphate of magnesia as the best aperient in enteritis and colitis, when one is required: (usually treatment by opium is to be preferred).

In true dysentery there is much evidence as to the value of the same salt, although it is not generally known. Trousseau called attention to it in 1826 (*Archives Gén.*, v., xiv.), Giacomini recognized it ("Treatise

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on Materia Medica"), and Stillé confirmed their observations: he gave about 60 gr., freely diluted, every two hours, with the result of at once diminishing tenesmus and bloody discharges, and inducing watery feculent stools: the treatment should be commenced early, and is best suited for sthenic cases: an occasional opiate at night may be given during the treatment. That the same method is equally available for chronic and debilitated cases is shown by the experience of Mr. Ford in Melbourne, when dysentery was for a long time epidemic and more severe in character than he had ever seen it in this country. Some of his patients (medical men and others) had suffered for many months, with only temporary relief from chalk mixture, laudanum, etc., when he gave them drachm doses of the sulphate, with 20 min. of sulphuric acid, every four hours, and a blue pill, with opium (1 gr.), at night. Mustard was applied over the abdomen, and farinaceous diet ordered. In the course of twenty-four to thirty-six hours, the dejections became feculent, with less blood, and in about nine days all irritation had usually subsided. Mr. Ford adopted this method on the hypothesis that excessive action prevailed in one part of the intestine (the colon), while the rest of it was inactive; and he hoped to "restore unity of action," and also to "eliminate morbid material." However this may be, he is able to report that, in seven years of extensive practice, he did not lose one case of dysentery in the adult (*Australian Journal* and *Ranking's Abstract*, i., 1859).

Hemorrhage.—Sulphate of magnesia is a valuable adjunct to astringent remedies for hemorrhage, because it helps to lessen arterial tension and capillary congestion at the same time that it obviates constipation. In *menorrhagia* it may be given with sulphuric acid; in *hæmoptysis*, with ergot, acid, and digitalis (H. Dobell); and in *hæmatemesis*, with alum and opium (Barlow).

Dysmenorrhœa.—In delayed and obstructed menstruation, when the discharge is scanty, dark, and of glutinous character, I have long prescribed the carbonate of magnesia with beneficial results, and especially when the irregularity is attended with sick headache and mental depression; it is most indicated in rheumatic subjects. Five to sixty or ninety grains may be given, according as to whether the constitutional, the laxative, or fully purgative action is required. The small dose should be given each night for the first fortnight after the cessation of the menses, and the larger doses during the latter fortnight, or especially before or during the period, or when headache and depression are present.

Lithiasis—Uric Acid Diathesis.—The power of magnesia to dissolve uric acid and to lessen its formation, whether directly or indirectly, has already been mentioned. Among other instances, Mr. Brande records that of a man, aged sixty, accustomed to pass much uric acid, and even calculi, and who had taken daily either 9 dr. of "subcarbonate" of soda, or 3 of potash, for more than a year without good effect, yet under the

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use of 60 gr. of magnesia thrice a day the acid soon diminished in amount, and after three weeks of continuous treatment it seldom recurred. Since Mr. Brande's memoir (1810) the remedy has been often used in similar cases. Sir B. Brodie combined 6 gr. of magnesia with 12 of potash bicarbonate and 15 of bitartrate, and it often acted well.

Chronic Gout.—Magnesia, in combination with its sulphate, and sometimes with colchicum in addition, was largely used by Sir Charles Scudamore, and with satisfactory result. It is especially adapted for the gastric derangements to which gouty patients are liable. In rheumatism its value is not so evident.

Diabetes.—In this malady, magnesia has been found useful by Hufeland, Willis, and others. It can only be considered as a palliative of some symptoms.

Warts.—Several curious observations have been recorded to the effect that warts disappear after a few weeks' use of carbonate of magnesia.

Irritant Poisoning.—As already mentioned, magnesia carbonate forms nearly insoluble compounds with arsenic and cobalt, and besides being used as an antidote to those poisons, it has been given with more or less success in cases of poisoning by corrosive sublimate, mercurial oxide, and salts of copper. It is perhaps best suited to neutralize the action of the strong acids, whether mineral or vegetable, and acts well when mixed with charcoal. When used for oxalic acid poisoning, large quantities must be given to form a basic insoluble salt (Husemann).

PREPARATIONS AND DOSE.—*Magnesia—magnesia levis:* dose, as an antacid, 10 to 20 gr.; as a purgative or adjunct, 20 to 60 gr. or more—4 to 8 gr. will purge an infant at the breast; children of about ten years require 30 to 40 gr. The *pulvis rhei compositus* (Gregory's powder) contains 6 parts with every 2 of rhurbarb and 1 of ginger. *Magnesiæ carbonas—magnesiæ carbonas levis:* dose, 10 to 60 gr.; 10 to 20 gr. as antacid, 20 to 60 gr. or more as a purgative. *Liquor magnesiæ carbonatis* should contain nearly 13 gr. in the ounce, but does not well retain this amount. The solutions of Henry, of Dinneford, and of Murray are original preparations of the same active ingredient (about 10 gr. to the ounce), and a convenient "double strength" preparation has been introduced by Kinmond. The bismuth lozenges B. P. contain about 2 gr. of the carbonate of magnesia. *Liquor magnesiæ citratis*, the "limonade purgative" of the French codex, may be taken in doses of 5 to 10 fl. oz. A "granular effervescent citrate of magnesia" is in popular demand, but was proved at a trial under the Adulteration Act a few years ago to be in reality a citro-tartrate of soda (*Pharmaceutical Journal*, 1873). I believe that an article containing at least some citrate of magnesia is now supplied. Magnesilyne is another form of the same remedy. Rochelle salt has also been found as an adulteration of it (*Pharmaceutical Journal*, February, 1873). In consequence of the high price of citric acid, a for-

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mula for producing a meta-tartrate of magnesia has been published (*Bulletin*, i., 1873). In the same journal, M. Martin records the rather important observation that even carefully prepared citrate, which is perfectly soluble when fresh, is apt to change with age into a subsalt, and to become insoluble. A "boro-citrate," made by dissolving a borate of magnesia in citric acid, has been recommended by Köhler for acid urinary deposits (*Medical Times*, ii., 1879). *Magnesiæ sulphas:* dose, 10 to 20 gr. for irritable conditions of the stomach, or in combination with astringents or tonics; when given with senna or other purgatives 30 to 60 or 120 gr., according to the frequency of repetition. For diuretic effects 20 to 60 gr., as a purgative in a single dose 2 dr. to ½ oz., according to the habit of the patient. Coffee and infusions containing tannin disguise the nauseous taste. *Enema magnesiæ sulphatis* (contains 1 oz. of the salt with 1 of olive oil, and 15 of mucilage starch). The *mist. sennæ composita* contains somewhat more than a drachm in each fluid ounce combined with senna and aromatics.

[PREPARATIONS, U. S. P.—*Magnesia; Trochisci magnesiæ:* magnesia 3 troyounces, nutmeg 60 gr., sugar 9 troyounces, mucilage of tragacanth sufficient; make 480 troches; *Magnesii carbonas; Liquor magnesii citratis; Magnesii sulphas.*]

MANGANESIUM—MANGANESE, Mn,=55.

Manganese is found in many ores, and generally associated with iron; the most common one is the black oxide, or per-oxide (pyrolusite), which is found abundantly in Great Britain and in various parts of Europe.

CHARACTERS.—Manganese is a grayish-white metal, hard and brittle, of sp. gr. 8. It emits a peculiar odor in a moist atmosphere, or if handled. When pure it oxidizes readily in the air, and hence is kept under naphtha, or in sealed glass tubes; it is dissolved by dilute sulphuric acid.

COMPOUNDS OF MANGANESE.

MANGANESII OXIDUM NIGRUM—BLACK OXIDE OF MANGANESE, MnO_2,=87.

CHARACTERS AND TESTS.—Occurs in brilliant needle-shaped crystals, or in compact masses, but is usually met with in the shops as a dull, earthy, dark-brown or black powder, which contains iron and other impurities. Treated with hydrochloric acid it causes evolution of chlorine, thus—

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

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When heated to redness, it gives off oxygen and leaves a residue of red oxide of manganese—

$$3MnO_2(\text{heated}) = Mn_3O_4 + O_2$$

Sulphuretted hydrogen causes in manganic solutions a flesh-colored precipitate of sulphide.

Manganesii Oxidum Preparatum (*not officinal*).—The prepared oxide is obtained by digesting the powdered black oxide in dilute hydrochloric acid for twenty-four hours, then levigating and drying.

MANGANESII SULPHAS—SULPHATE OF MANGANESE, $MnSO_4 5H_2O$, = 241 (*not officinal*).

CHARACTERS.—Occurs in colorless, or pale rose-colored, transparent crystals, freely soluble in water.

The *double sulphate*, the *double carbonate*, and the double *iodide, with iron*, are sometimes prescribed; less frequently such compounds as the *lactate, phosphate, citrate*, and *valerianate of manganese* (Hannon, Guibert). None of them are officinal.

Permanganate of potash (*v.* p. 267).

ABSORPTION AND ELIMINATION.—Salts of manganese undergo probably the same changes in the stomach as salts of iron, and are absorbed as albuminates, or as chlorides. The metal, like others, is eliminated mainly by the bile and the intestinal tract. W. Turner found distinct evidence of manganese in the urine of a diabetic patient who had been taking permanganate of potash freely for three weeks, showing that it is, at any rate, partly eliminated by the kidneys (*Edinburgh Medical Journal*, vol. vi., 1861).

PHYSIOLOGICAL ACTION (INTERNAL).—*Circulatory System.*—The presence of manganese as an essential element of the corpuscles has been relied upon as a guide to its action, but it seems to be rather an accidental than a normal constituent of the blood. Wurzer, in 1830, first announced its presence, and Millon, Hannon, and Burin-Dubuisson corroborated this, while Melsens, Bonnewzn, and others, could find no manganese on repeated analyses; Melsens operated on 7 kilogr. of blood from twenty-one different persons. M. Glénard analyzed, in various ways, blood from forty subjects of varying age and sex, and found the metal in one case only. He concluded "that manganese is not an essential element of human blood; it may be found accidentally, but only in minute amount; it does not enter by the lungs or skin, as proved in the case of a miner" (*Gazette Médicale de Lyon*, 1854). I have not met with any series of analyses for manganese since those quoted. M. Riche, the latest observer, who finds the galvanic test to be exceedingly delicate, has detected minute quantities in the blood of bullocks, etc., but has not tested human blood often enough to speak with authority (*Medical Record*,

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1877). Bartholow, however, considers the question decided affirmatively, and even gives the proportion of manganese to iron in the red corpuscles (human) as 1 to 20. If this be so, we may agree that the administration of manganese would be likely to improve the nutrition and the color of the corpuscles in a direct manner, but so much as this cannot yet be positively stated from physiological research. That manganese has a similar action to that of iron has been often stated, but must be considered problematical (Husemann), and indeed, the increased blood-pressure caused by the latter is not produced by the former drug.

According to Laschkewitz, the organic salts of manganese, in moderate doses, slow the pulse and the heart-action, and cause lowering of blood-pressure, and paralysis of muscles and nerves, which iron certainly does not. After death from manganese poisoning the heart is found dilated, and does not respond to electrical stimulation.

Nervous System.—Certain nerve-phenomena, whether direct or indirect, are determined by manganese salts. Toxic doses cause death with convulsions, and ½ to 1 gramme injected into the veins of rabbits or dogs produces cramp and death from heart-palsy, or else faintness and weakness and slower death with fatty degeneration (Laschkewitz). The pupils are dilated, the temperature unaffected. Rabuteau injected a little more than 1 gramme into a vein of the hind leg of a bitch, and at first there were no symptoms, but on the following day tetanic convulsions set in, with trismus and opisthotonos, and death followed shortly afterward: the white substance of the spinal cord was shrunken, the gray matter congested.

Large doses given for a long period induce effects analogous to those of zinc—progressive wasting and feebleness, a staggering gait, and paraplegia (Bartholow).

Digestive System.—The saccharated carbonate of manganese has no peculiar taste, the sulphate is styptic, metallic, and disagreeable. Small doses (5 to 10 gr.) of these salts are said to promote appetite and digestion, but larger quantities are apt to irritate, and cause vomiting and purging. The oxide, which is gritty on the tongue, is said to exert rather a sedative action on the gastric membrane.

The sulphate of manganese has been especially credited with the power of stimulating the secretion of bile since the observations of C. G. Gmelin, who found in animals poisoned by large doses, inflammation of the stomach, intestines, etc., and "so large an amount of bile poured out that the whole tract was colored like yellow wax." He reported a less degree of the same effect in man, and Mr. Ure also found that 60 to 120 gr. acted as a cholagogue purgative (Pereira). Dr. Goolden took various doses, from 1 up to 30 gr., before any vomiting occurred, but states that as a rule 10 to 20 gr. will cause some nausea and free purging with copious secretion of bile (*Lancet*, 1840, and i., 1878). Dr. Rutherford, how-

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ever, failed to corroborate this experience, at least in animals, for after giving 60 gr. to a dog the biliary secretion was at once lessened and severe diarrhœa occurred. After death the mucous membrane of the small intestine was found pulpy, "as if the epithelium had been dissolved by caustic." In another dog a dose of 20 gr. equally caused lessening of bile, although benzoate of soda given afterward had power to restimulate its secretion. Dr. Rutherford concludes that the drug is a powerful intestinal, but not an hepatic stimulant, acting very like sulphate of magnesia (*v.* p. 235). Nitrogenous excretion is increased by it. Poisonous doses induce acute fatty degeneration of the liver, like phosphorus.

SYNERGISTS.—Iron may be considered as allied in action to manganese within the limits of the preceding observations; the two substances are constantly associated in nature. Copper, silver, and zinc have allied effects on the nervous system. Goolden speaks of sulphate of manganese as substitutive for mercury as regards the action on the liver, but this is doubtful. He says also that it aids the action of sulphate of magnesia, and Rutherford has shown some analogy between these two salts.

ANTAGONISTS AND INCOMPATIBLES.—Caustic alkalies and salts of lead, silver, and mercury are *chemically* (not therapeutically) incompatible with manganese. Tannic acid and vegetable astringents are not incompatible, as they are with iron.

THERAPEUTICAL ACTION (EXTERNAL).—*Hemorrhage, etc.*—The chloride of manganese and iron has been used by M. Pétrequin, in preference to the simple perchloride of iron, as a local hæmostatic; and in Italy it has been applied to necrosed bone, and injected into fistulous tracts and hydroceles (*Practitioner*, vol. v., p. 375), but it has no proved advantage over other well-known remedies.

Skin Disease.—The same remark applies to the use of an ointment made with the oxide of manganese (℥ ij. to ℥ j. adipis), which has been recommended in *scabies* and *ringworm*, and, combined with sulphur, in *porrigo*.

Disinfectant.—Free chlorine is readily and cheaply generated by acting on peroxide of manganese with hydrochloric acid, or by heating a mixture of common salt and peroxide with sulphuric acid and water (equal parts). The former process is recommended in the Swedish Pharmacopœia, 1 part of peroxide (pyrolusite) and 4 of acid being ordered: the latter process is that known by the name of Guyton Morveau: a mixture of manganese oxide 7½ grammes, and 10 grammes of salt, with sulphuric acid and water, of each 20 parts, will disinfect a space of 30 c.m.

THERAPEUTICAL ACTION (INTERNAL).—*Anæmia—Chlorosis.*—Manganese was introduced into practice mainly by M. Hannon, of Brussels, with special reference to the treatment of these conditions. He argued that, during digestion, sulphuretted hydrogen is formed, and reacts on the ferrous and manganic compounds contained in the intestines, chang-

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ing them into insoluble sulphides, and thus removing essential elements of hæmatosin. This happens especially (he supposes) in chlorosis, and the remedy is to supply more of a metal which can form such sulphides, and prevent the removal of essential elements of the organism. Hence, bismuth, lead, and copper are said to prove as serviceable as iron or manganese, though the latter are better assimilated (*Presse Médicale Belge*, 1850, and Guibert). M. Hannon goes even further than this, and describes three forms of chlorosis, according as there is a deficiency in the blood of iron only, of manganese only, or of both metals. Thus, in the first case, there are "earthy tint of skin, weakness of locomotor system, slow, regular pulse, diarrhœa, and fluid menstrual discharge." In the second case, "color of skin and mucous membranes normal, pain in muscles, constipation, amenorrhœa." In the third case, "waxy tint, bluish sclerotics, œdema, serious nerve-disturbance, derangement of circulation, dyspnœa, low temperature, uterine pain." According to such symptoms does he recommend either iron alone, manganese alone, or a combination of both metals. It is evident that these statements are largely theoretical; and, apart from the fact that even the necessary presence of manganese in the blood of healthy persons is doubtful, an appeal to clinical results does not bear out the suggestion of its great importance as a hæmatinic remedy—rather the contrary. M. Hannon himself reported very good effects from it, and Dr. Steer (Cheltenham) saw benefit in chlorotic anæmia, traumatic anæmia, and in phthisis, and in anæmia of children; but he used saccharated carbonate of manganese with iron, not manganese alone. In uterine leucorrhœa of pale weakly subjects, he gave it with ergot; for constipation, with aloes; for dyspepsia, with soda and rhubarb (*Medical Times*, ii., 1853). Sir J. Simpson found the phosphate sometimes useful in amenorrhœa, given either with or without iron, but says very little about it (*Medical Times*, i., 1861, p. 517). Dr. Broadbent, using the chloride and sulphate, reported some favorable, some negative, results. Mr. Carter used it with no good effect ("Clinical Society's Transactions"), while Dr. Garrod failed to cure every case of anæmia in which he employed the manganese salts alone, and the subsequent administration of iron was always followed by rapid improvement. It is true that M. Pétrequin was an enthusiastic advocate for the remedy in all forms of impaired blood-condition, including intermittent fever, phthisis, and cancer, but the general experience of the profession is not with him or M. Hannon. All we can at present say is, that in obstinate cases of chlorosis not cured by iron, the conjunction with manganese should receive further trial.

Hepatic Disorder.—I have already mentioned that Mr. Ure found 1 to 2 dr. of the sulphate act as a cholagogue purgative (Pereira), and Dr. Goolden gave it in cases of enlarged liver with dark or pale stools, and jaundice, when no abscess or acute symptoms were present. Most of the patients (at the Dreadnought Hospital) were in weak condition, having

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returned from India, and he sought for a non-mercurial remedy to stimulate the liver. He says that 10 or 20 gr. of sulphate of manganese, though at first it excited nausea or vomiting, soon acted on the bowels to the marked relief of the patient, and with rapid clearing away of the jaundice (*Lancet*, 1840). This favorable result has, however, not been corroborated by the experience of others, but recently Dr. Goolden has written to direct attention again to the subject, stating that he has continued to use the remedy with success in hepatic dropsy, hemorrhoids, bronchial congestion, hypochondriasis, etc.: he usually combines it with Epsom salts, in a glass of effervescent water (*Lancet*, i., 1878).

Polli and Galamini state that they have cured cases of biliary calculus by peroxide of manganese, given in gramme doses daily as an electuary: they explain the solution of the calculi by the action of oxygen from the peroxide upon the cholesterine (*Gazette de Paris*, 1856).

Gastrodynia—Pyrosis.—Dr. Leared found that purified oxide of manganese had decided power in relieving these disorders; he describes epigastric pain, severe and radiating, coming on not immediately, but soon after food, worse after albuminous food; the tongue generally red and patchy, and the malady connected with too rapid shedding of epithelium and exposure of a hyper-sensitive mucous surface; pyrosis and vomiting are sometimes present.

Bismuth is a usual and excellent remedy for such a condition, but Dr. Leared found manganese relieve it often more quickly, with the advantage of not causing constipation. He states that he has treated several hundred such cases with satisfaction, before venturing to recommend it (Ranking, i., 1864). No mention is made of a drawback described by Dr. Goddard Rogers, whose patients found the medicine so gritty and unpleasant that they could scarcely continue it. He reports two cases of gastralgia, "severe pain with occasional vomiting," one case of stomach derangement sympathetic with the uterus, and one of pyrosis, with "irritable mucous membrane." All these got well rather quickly, with 10-gr. doses of the oxide (*Lancet*, i., 1864, ii., 1865). We have not, however, heard much of this remedy from other observers.

PREPARATIONS AND DOSE.—*Manganesii oxidum preparatum:* dose, 5 to 10 gr. *Manganesii sulphas:* dose, 10 to 20 gr. as a purgative. *Ferri et manganesii carbonas saccharata:* dose, 5 to 10 gr. as a hæmatinic. Solutions of manganese salts are apt to change color on exposure to the air.

[PREPARATIONS, U. S. P.—*Manganesii oxidum nigrum*, and *Manganesii sulphas.*]

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PLUMBUM—LEAD, Pb,=207.

This metal, rarely found in its native state, occurs more often combined with sulphur or oxygen. Its commonest ore is galena, a glistening gray sulphide, PbS, from which the metal is obtained by roasting it in a current of air; it is not used in medicine.

Compounds of Lead.

PLUMBI OXIDUM—OXIDE OF LEAD—LITHARGE, PbO, =223.

Preparation.—By roasting lead ores with access of air, when the oxide is formed in a melted state, and separates on cooling.

Characters and Tests.—Occurs in small glistening red or yellowish-red scales, which should dissolve without effervescence in dilute acids, but after exposure for some time to the air, the scales slowly absorb carbonic acid and may then give some effervescence; they are soluble also in excess of potash.

The following *tests* are applicable to this, and to all soluble salts of lead:—(1) Sulphuric acid and soluble sulphates give a white precipitate (sulphate of lead) insoluble in dilute acids; (2) iodide or chromate of potassium gives a yellow precipitate of iodide or chromate of lead; (3) sulphuretted hydrogen or sulphide of ammonium gives a black precipitate of sulphide of lead, but if the proportion of lead be minute, the color is brown rather than black (W. G. Smith).

PLUMBI ACETAS—ACETATE OF LEAD—"SUGAR OF LEAD," $Pb(C_2H_3O_2)_2 3H_2O$, =379.

Preparation.—By dissolving lead oxide in slight excess of acetic acid by aid of gentle heat, then crystallizing.

Characters.—Occurs in white crystalline lumps, not unlike sugar, or in large four-sided prisms. The odor is somewhat sweet and acid, and the taste at first sweet, afterward astringent. It effloresces in air, and is soluble in water; with distilled water the solution is clear, but with ordinary water it is turbid from the formation of carbonate of lead with the alkaline carbonates always contained in such water; a few drops of acetic acid will dissolve the carbonate and clear the solution.

LIQUOR PLUMBI SUBACETATIS—SOLUTION OF SUBACETATE OF LEAD—"GOULARD EXTRACT," $Pb(C_2H_3O_2)_2 PbO$(in water), =548.

Preparation.—By boiling neutral acetate of lead with two-thirds of its weight of oxide of lead, then filtering, and adding distilled water: a basic or subacetate of lead is formed.

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CHARACTERS.—A colorless liquid of alkaline reaction and sweetish astringent taste. It quickly absorbs carbonic acid from the air, and becomes turbid from formation of carbonate. It gives precipitates with most vegetable coloring matters, with tannin, and with many animal substances, especially albumen. With gum it forms an opaque white jelly, which the acetate of lead does not. It answers to the other tests of lead already mentioned.

PLUMBI CARBONAS—CARBONATE OF LEAD—"WHITE LEAD," $2PbCO_3PbO,H_2O,=775$.

PREPARATION.—No process is given in the Pharmacopœia, but the carbonate is prepared on a large scale by exposing thin sheets or gratings of lead, placed in earthen pots, to the combined action of acetic acid, air, and carbonic acid gas.

CHARACTERS.—A heavy white powder, insoluble in water, but readily soluble in dilute acids, with effervescence.

PLUMBI IODIDUM—IODIDE OF LEAD, $PbI_2,=461$.

PREPARATION.—By precipitating a clear solution of nitrate of lead with iodide of potassium, washing, and desiccating.

CHARACTERS.—A bright yellow powder, darkened by heat, almost insoluble in cold water, soluble in boiling water, from which it is deposited in golden crystalline scales; soluble in solution of acetate of sodium. It fuses and sublimes yellow, but soon gives off violet vapor (Garrod).

PLUMBI NITRAS—NITRATE OF LEAD, $Pb(NO_3)_2,=283$.

PREPARATION.—By dissolving lead, or its oxide or carbonate, in boiling nitric acid, slightly diluted, then crystallizing out.

CHARACTERS.—Octahedral crystals of white waxy appearance, and sweetish, astringent taste, soluble in water and alcohol, not efflorescent.

ABSORPTION AND ELIMINATION.—Soluble lead compounds, when introduced into the stomach, are transformed probably into chlorides, but in any case are readily absorbed, as shown by clinical results; it is presumed that they circulate mainly as albuminates.

Workers in lead, such as compositors, plumbers, and painters, absorb the metal in part by the skin, in part by the lungs, and sometimes directly with the food (from eating with unwashed hands), and injurious effects are not uncommon from the application of cosmetics and dyes containing lead, to the skin and hair (*v.* p. 257). Once within the system lead remains for a long time, in small quantities at least, and may be deposited in different organs. It has been found not only in the blood and

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in the liver, spleen, and kidney, but also in the muscles and bones, and Chatin recovered 3 milligr. of lead sulphide from 150 grammes of the upper cervical cord—the tissue was dark gray in color (*Comptes Rendus*, Soc. de. Biol., t. iv., 1862). Lead is *eliminated* chiefly in the form of chloride through the liver, kidneys, skin, and mucous membranes, especially those of the urinary tract; the process is markedly promoted by iodide of potassium.

(It will be seen from the above observations that I cannot accept the conclusions of Mayençon, "that lead is not absorbed by the skin," and that after being taken, "its elimination is prompt and complete"—*Medical Times*, i., 1873, p. 489).

Physiological Action (External).—Solutions of acetate and nitrate of lead, if not too strong, exert a local astringent and sedative action, coagulating albumen, contracting the vessels, blanching the tissue, and controlling congestion if present; on the other hand, if the solution be too strong, and be applied to a delicate part, such as the conjunctiva, it excites severe irritation. The carbonate of lead, applied in fine powder, is sedative and slightly astringent. The iodide is slightly stimulant and absorbent. The nitrate and chloride decompose sulphuretted hydrogen, combining with the sulphur, and hence they act as deodorants.

Physiological Action (Internal).—*Digestive System.*—The acetate and subacetate of lead are the only salts of this metal given internally, and the effect of moderate medicinal doses upon the intestinal tract is to diminish its secretions and to occasion sometimes slight colic. The more pronounced effects of poisonous doses vary with the mode of receiving them, and may be acute, subacute, or chronic in character.

Acute poisoning.—After a dose of from 1 to 2 oz. the symptoms begin quickly with the characteristic taste of the drug, followed, perhaps, in a quarter of an hour by burning and pricking in the gullet, nausea and vomiting, but the vomiting caused by the poison alone is not usually severe; there is uneasiness in the stomach sometimes followed by violent colic, but the pain intermits, and it may be relieved by pressure. There is usually constipation, but sometimes an attack of purging, the fæces being dark, and containing lead sulphide.

Subacute poisoning may be illustrated by cases which occurred at Stourbridge in 1849, when acetate of lead was mixed by accident with flour at a miller's. Upward of five hundred persons were attacked, a few days after eating the bread, with a sense of constriction about the throat and stomach, cramping pain near the umbilicus, and rigidity of abdominal muscles; sickness occurred only in a minority of the cases, and did not last long; there was obstinate constipation and a general lessening of secretion; a dark blue line on the gums was noted. No cases were fatal, but severe symptoms continued for a long time, and sometimes recurred after apparent convalescence.

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The subject of *chronic lead-poisoning* is exceedingly interesting to the practical physician, but concerns us at present only as illustrating the physiological action of the drug. Some of its symptoms have occurred from the medicinal use of the acetate, and from the continued use of minute quantities rather than from massive doses. Thus, Sir R. Christison gave 18 gr. in two days without injurious effects, while $\frac{1}{15}$ gr. given two or three times daily for two months caused fatal poisoning in a child (Letheby, Taylor). As a rule, it may be said that the worst effects of any medicinal use of lead limit themselves to an attack of colic, and the severe symptoms about to be described need not be feared from it: 5-gr. doses of acetate are largely used at Brompton Hospital without bad results.

The ordinary "lead colic," or plumbism, is traceable most frequently either to the mechanical use of metallic lead, its oxides or carbonates, or to the solution of these salts in drinking-water, etc. (*v.* p. 257). After some general malaise, disordered taste, dryness of mouth, fetid breath, anorexia, and constipation, pain will usually be the most marked symptom, but is not so invariably; Dr. Garrod finds it absent in 2 or 3 per cent. of cases. When fully developed, it is much more intense than ordinary colic; it is referred mainly to the region of the navel (the colon), but darts rapidly, like neuralgic pain, in many directions, toward the loins, the scrotum, the chest, and the thighs: it has a twisting, tearing character, so that German miners name it commonly "Hütten Katze" ("cat of mines"). It comes on in paroxysms, remaining constant but dull in the intervals, and the whole attack lasting from a few minutes to several hours; it is often worse at night, but its recurrence is irregular. Relief is found from firm pressure and altered position, and the sufferer either lies flat on his face, pressing the abdomen, or is doubled up, bending his legs, or rises suddenly, still pressing the painful part with his hands, till a violent paroxysm again sends him to bed. Restlessness is extreme, and the whole attention is concentrated on the pain. The abdominal walls are rigid, knotty, and drawn in, there is commonly tenesmus, and the rectum has been felt to contract and relax spasmodically. The liver is retracted (Potain) or actually lessened in size; the intestines also are drawn into less space from contraction of their muscular coat, and in prolonged cases, after the abdominal fat has been absorbed, the retraction of the belly becomes very striking.

Tanquerel (*Traité des Maladies de Plomb*, Paris, 1839) and Burton ("Medico-Chirurgical Transactions," 1840) were the first to describe as common in plumbism a dark blue or gray line along the free edge of the gum, together with a brownish coloration of the teeth. Though a valuable sign, and often present, it is not always so, nor does it necessarily imply saturation of the system with the mineral; it varies in its time of appearance according to the dose, but has been seen within twenty-four

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hours of administration of one large quantity (Burton): 20 to 30 gr., in divided doses, may develop it, and when once seen it is very persistent; similar colored patches may often be found on the buccal mucous membrane. The coloring depends on formation and deposition of lead sulphide from the sulphuretted hydrogen evolved from particles of food left about the teeth (Tomes), and by perfect cleanliness it may be prevented. According to Dr. Hilton Fagge, it is distributed in rounded loops corresponding with vascular papillæ of mucous membrane, and depends on small pigmented granules, some of which are external to, others within the small vessels. He concludes that the gas from food-particles diffuses into the gum-textures, and then combines with lead circulating in blood or plasma, so that particles of lead sulphide are really precipitated—a similar condition may be present in the intestinal membrane. Iodide of potassium sometimes induces its rapid development (*Lancet*, i., 1876, p. 709).

We cannot so readily explain the pathology of the colic. It is in part dependent on constipation, or accumulated mucus within the canal, for it is relieved when purgation is secured; yet Briquet claims to have relieved more quickly by faradaism of the abdominal wall without any aperient effect. It is dependent partly also on irregular muscular contraction of the intestinal tube, following on partial paralysis and spasmodic peristalsis; other characters again show it connected with an enteric neuralgia (*v.* p. 254).

In acute poisoning, the gastro-intestinal mucous membrane has been found coated with a whitish-gray layer of coagulated mucus containing the poison, and there have been patches of abrasion, congestion, or inflammation. In chronic cases the membrane is congested, softened, and discolored, the walls are thickened, and the canal irregularly contracted; sometimes intussusceptions are found; the coils of intestine are closely packed together. In chronic plumbism, emaciation is notable, especially about the face.

Nervo-Muscular System.—Ordinary medicinal doses do not usually produce definite effects on the nerves or muscles, but in acute poisoning from large quantities, besides the pain and cramp already mentioned, general prostration is a marked symptom. There may be also giddiness or stupor, numbness or paralysis, and, in fatal cases, convulsion. In the subacute cases at Stourbridge, the nervo-muscular symptoms were cramp and rigidity of muscles, numbness, and partial palsy of lower extremities, and collapse: the mental faculties were unimpaired.

But it is in chronic plumbism that affections of the nerves and muscles become marked and significant, various forms of paralysis almost always appearing. The most common is a paralysis of the extensors and supinators of the forearm, leading to a condition known as "wrist drop," from the peculiar manner in which the hand hangs down when

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the limb is extended. This occurs more often on the right side than the left—the fingers and wrists are flexed and the hand prone, the elbow stands out from the side, and the forearm bends on the arm—wasting of the affected muscles quickly follows, and especially of the small muscles of the thumb.

A special plastic or fungoid form of synovitis in the sheath of the extensor tendons has been described (Gubler: *British Medical Journal*, ii., 1878).

Sometimes other muscles are affected—thus, strabismus has been noted from paralysis of ocular recti, and aphonia from laryngeal palsy. Occasionally hemiplegia occurs, more rarely still paraplegia, and in advanced cases the extensors, at least of the lower limbs, are more or less affected. Death has resulted from paralysis of respiratory muscles. Of the special senses, sight is the most often affected, amblyopia occurring, or amaurosis from anæsthesia of optic nerve; in such cases the pupil is dilated. It is not uncommon for the hearing to suffer, and common sensibility is often altered. There is usually partial anæsthesia, though sometimes, as in the Claremont cases, excessive hyperæsthesia is developed.

During an attack of lead colic the intellect is, as a rule, clear, but in continued cases the moral courage and the spirits give way, and sometimes in the course of the illness distinct delirium occurs, generally of the form "delirium of dread," not unlike delirium tremens. The patient is extremely fearful of being alone, especially at night, and has visions of black and creeping things. Three remarkable illustrations occurring in women-workers at a lead-factory are furnished from the London Hospital (*Medical Times*, i., 1869). Other cerebral symptoms, such as headache, delirium, epileptiform convulsions, and coma, have been recorded; insomnia is usual.

Theories of Plumbism.—Whether the muscles or nerves are primarily affected, and in the latter case whether the peripheral branches or the centres are most at fault, has been much debated. Giacomini attributed the *colic* to direct muscular irritation from deposition of the metal in the abdominal muscles and the diaphragm, pointing out that superficial pressure often gives pain, even over the iliac crests (where the intestines are not), while firm supporting pressure relieves. Briquet, acting upon this theory, faradized the skin of the abdomen with a metallic brush, and thus relieved the pain by counter-irritation. That the *paralysis* also depends on deposition of the metal in the muscles is suggested by the frequency with which the right arm is affected in lead-workers, it being more exposed to the poison than the left.

Tanquerel maintained that the colic was due to irritation of the great ganglionic centres, though signs of this could only be found in one out of forty post-mortem examinations. It may be noted, however, that gal-

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vanism of the sympathetic nerve-centres has been said to cause elimination of the poison quickly, and to cure palsy of the forearm without direct local treatment (*Medical Times*, i., 1877).

Eulenburg considers lead colic "a mixed neurosis of motor-sensory nature, in which the splanchnic nerves and vaso-motor branches from the aortic plexus are affected" (*Medical Times*, i., 1870). He points out the special determination of lead to the muscular system and its powerful local effect in causing contraction of involuntary muscles.

Heubel argues that the peripheral intra-muscular extremities of nerves are at fault rather than main trunks ("Bleivergiftung," Berlin, 1871), and Althaus apparently takes the same view (*Medical Times*, i., 1874, p. 548). On the other hand, Bernhardt asserts that the real lesion is in the gray matter of the cord (*Medical Record*, 1878), and most modern observations point to the same conclusion, at least in chronic conditions; lead has been found in its substance in some cases (Chatin, *v.* p. 251), and a granular partly atrophic state of spinal cells has been verified in one instance by Lancereaux. The affected muscles and corresponding nerve-trunks are much atrophied, so that sometimes scarcely one normal fibre can be found.

Circulatory System.—Full medicinal doses of the acetate slightly lower the force and frequency of the pulse (Laidlaw). In hemorrhagic cases and in pneumonia this effect is often marked. Strohl found a diminution of ten to fifteen beats per minute after daily doses of 25 to 50 ctgr., and Rabuteau verified a pulse-rate below that of health; it has been explained by a direct action on the muscular structure of the heart. In cases of *acute* lead-poisoning, the pulse has been sometimes quickened, but has become slow in the stage of collapse. In *subacute* cases it is markedly slow and feeble. During a paroxysm of colic in the course of plumbism the pulse is of characteristic wiry hardness, and generally lowered in frequency, while the heart-action is so weakened as to be scarcely perceptible. In half the large number of cases recorded by Tanquerel, the pulse-rate was from 30 to 60 per minute, the hardness and slowness being usually proportioned to the amount of pain; exceptionally the frequency was increased. The peripheral circulation is commonly impeded, and arterial anæmia leads to pallor and chilliness, though in two cases recorded by Murchison a rise of temperature (102°) was found (*Lancet*, i., 1868). In *chronic* conditions of lead-poisoning the pulse is small, hard, and usually slow, and the sallow, bloodless skin has an icteric tint, anæmia is commonly marked, and there is more than normal water in the blood as well as fewer red globules; Malassez states, however, that these are increased in size (*Archives de Physiol.*, 1874). Cardiac murmurs are usual in lead-workers, and it is said that the heart and great vessels have been found smaller than usual after death. Henle considers that the vessels are contracted (during life) by direct irritation of their muscular coat by

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lead circulating with the blood; certainly vascular tension is much increased in plumbism, as clearly shown by the sphygmogram of Dr. A. Frank (*Deut. Arch. Klin. Med.*, Bd. xvi., Hft. 3). German observers, besides corroborating this, have demonstrated the antagonistic effect of pilocarpin during attacks of colic; very soon after its hypodermic injection the tracing shows greatly lessened tension, and simultaneously the pain is relieved. Nitrite of amyl acts similarly (*Medical Record*, 1876).

Genito-urinary System.—Chronic lead-poisoning often leads to abortion, and if this does not occur, the children born are delicate. Of 123 conceptions among lead-workers, 50 children only were born alive, and of these but 14 survived infancy. It would seem that the influence of one parent only affected by lead is enough to produce these results (M. Paul: *Archives de Méd.*, 1860). Amenorrhœa has been clearly traced by Dr. Dowse to working in lead.

The influence exerted by this drug upon the kidney is of great practical importance: albuminuria is not uncommon in acute plumbism, and is then connected probably with altered blood-conditions, but in chronic cases a directly injurious action is exerted on the kidney structure, leading to fatty or albuminoid degeneration. Dr. Shearman has recorded two remarkable instances of albuminuria in one family, clearly traceable to the use of drinking-water impregnated with lead—characteristic palsy was also present. The cases recovered for a time after removing the cause, but later, one died of apoplexy, the other of albuminuria (*Practitioner*, vol. xii.).

During a paroxysm of colic the kidney secretion is diminished, and is passed with difficulty. It is proved, also, that the withdrawal of urates from the blood in its passage through the kidneys is lessened under the influence of lead, and the amount of uric acid excreted by the same organs is lessened, hence a larger than normal amount remains in the blood, and the patient becomes exposed to gouty attacks. Indeed, both Dr. Garrod and Dr. Ringer have developed acute gout in susceptible subjects by the administration of lead salts, and the former has calculated that 33 per cent. of gouty patients had been exposed in some manner to the action of lead. Pains about the joints, and urate deposits, are not uncommon in saturnine cachexia. Dr. Wilks adds testimony to their frequency (*British Medical Journal*, i., 1875).

Glandular System.—By the ordinary medicinal use of the drug all secretions are diminished. According to Rutherford, the acetate of lead is the only substance which lessens the secretion of bile without causing purgation, and he considers this action to be direct, not indirect or reflex; it is overcome by salicylate of soda. He connects the constipation partly with this action on the liver, partly with similar action on the intestinal glands (*British Medical Journal*, ii., 1878). Heubel attributes the icteric condition frequent in plumbism to contraction of the bile-ducts (muscular

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fibres). During an attack of colic, all the secretions are diminished except that of the skin (Alderson: "Lumleian Lectures," 1852, *Lancet*).

Modes of Chronic Lead-poisoning.—Of the different workers in lead, oxide of lead, or "white lead" (carbonate), those who grind it in factories are most liable to suffer, though less so now that the powder is ground with water (Taylor); but house-painters and coach-painters, plumbers, pewterers, and compositors, makers of certain white glazed cards, hat pressers, bleachers of Brussels lace, and glazers of pottery, are often affected. Severe symptoms have sometimes arisen from sleeping in a newly-painted room, or from breathing the smoke of burning painted wood. Among exceptional and little suspected causes of plumbism, are the handling of vulcanized rubber and black horse-hair colored by lead sulphide, the use of hair washes, dyes, and cosmetics containing lead salts, breathing dust from "American cloth" whitened with lead salts, and in the process of making yellow cord fusees (chromate of lead). Poisonous symptoms have followed in an infant after the application of strong lead lotions to the mother's nipples, and in children from yellow confectionery (chromate); the chewing of "tea lead" (in which tea is wrapt), the using of snuff that had been wrapped in similar "foil," the use of soda water from lead "syphons" (*British Medical Journal*, 1874–75)—(free tartaric acid is said to help in this case)—bathing in water impregnated from a leaden pipe, the drinking of wine from bottles which had been cleansed with shot—have all caused plumbism.

Two curious epidemics have occurred—one at Taunton, another in France—from flour ground between millstones that had been mended with lead (*British Medical Journal*, 1877; *Medical Times*, i., 1878), and even the handling of lead machines, as in ice-cream making, or cameo polishing, or cleaning "beer engines" or brass handles (as engineers do), has induced colic.

There is some reason to think that the "dry colic," or enteric neuralgia, of tropical countries is connected with lead. Gubler gives instructive instances of its development from the use of lead cosmetics in creoles (*Medical Record*, 1876), and it is said to have become more common since steam-boats have been more used! (*Medical Record*, 1876). Mialhe and other French physicians also speak of lead colic being frequent on shipboard, and connect it with the action of a saline atmosphere on lead engines, etc.

But excepting the trades first mentioned, the most frequent source of lead-poisoning is the use of drinking-water impregnated with the metal or some of its compounds. Bad symptoms have resulted from so small an amount as $\frac{1}{40}$ gr. per gallon, and 1 gr. per gallon is a surely dangerous dose. It is to be noted that the freer the water from saline ingredients, the more readily it takes up a soluble carbonate formed on the metal pipe or cistern. Its formation and solubility are also favored by much organic

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impurity, free access of oxygen, a little nitric acid (as may happen after thunder-showers), or the presence of a second metal (iron as well as lead). Carbonic acid in pure water also favors solubility, although in certain circumstances it may act differently. Lime and other saline constituents will, on the other hand, if present in the water, *lessen* liability to contamination by forming insoluble coatings on the metal: otherwise, no doubt, plumbism would be still more common than it is.

Idiosyncrasy.—There is a great difference in the susceptibility of different individuals to the poisonous action of lead—as may be verified in any large factory—and it is comparable to what has been noticed with arsenical wall-papers, etc. One attack of colic strongly predisposes to another, which may follow after a long interval from comparatively slight cause—thus, a man who had suffered as a house-painter, turned game-keeper, and got an attack long afterward from stirring shot in water with his hands (*British Medical Journal*, i., 1877).

SYNERGISTS.—The depressing influence of lead upon the circulation is assisted by digitalis, ergot, veratrum, prolonged cold, etc.; its astringent action by metallic salts of copper and zinc particularly. The other metals, especially mercury, antimony, and copper, have a similar effect in lessening nutrition.

ANTAGONISTS AND INCOMPATIBLES.—Sulphate and carbonate of lime, carbonic acid, acids mineral and vegetable, alkalies, iodide of potassium, opium, albuminous solutions, and most vegetable astringents are chemically incompatible, and most of these may be used in the treatment of lead-poisoning. In acute cases, when the drug has been taken by the mouth, emetics or the stomach-pump should be used, and sulphate of soda or magnesia given in milk or mucilage. In chronic cases, alkaline iodide should be given internally, and sulphur baths should be used, containing about 7 oz. of sulphuret of potassium. During half an hour of bathing, frictions should be employed, and soap should be freely used afterward (Eulenburg). Electricity should be applied to the affected muscles—faradaism if it causes contraction, if not, the continuous current three or four times weekly for about a quarter of an hour, whether it induces contraction or no: in curable cases it will ultimately do so. Purgatives should be freely given. Fatty food is said to antagonize the development of plumbism in lead-workers, and a long prevalent colic in large lead-works at Birmingham was stopped by the free use of a "treacle beer," containing sulphuric acid (*Lancet*, i., 1860). Washing the hands before eating, etc., is important, and washing with petroleum is said to be prophylactic (*British Medical Journal*, ii., 1877).

Pilocarpin and amyl nitrite antagonize the increased arterial tension which occurs in chronic cases (*v.* p. 256).

THERAPEUTICAL ACTION (EXTERNAL).—*Disinfectant Power.*—A solution of lead nitrate (Ledoyen's disinfectant) has been in use for many

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years, and acts by decomposing sulphuretted hydrogen, but has no other good effect; it is comparatively expensive, and its black precipitate is sometimes objectionable: Dr. Goolden has, however, recently recommended as applicable to many cases, solution of *chloride* of lead, although it also can act only on sulphuretted hydrogen. He prepares it by dissolving ½ dr. of powdered nitrate of lead in one pint of boiling water, and mixing this with 2 dr. of common salt in 2 gallons of water. The precipitate which falls is in part carbonate of lime, in part carbonate of lead, and the clear supernatant fluid is a saturated solution of lead chloride. This quickly removes the smell of foul drains, ship-holds, etc., and cloths wrung out of it, and placed about a room, neutralize organic emanations, *e.g.*, from crowded assemblies, fetid suppuration, etc. It was used with much advantage on board the *Thunderer* after a gun-explosion (*Lancet*, ii., 1875, ii., 1876; *British Medical Journal*, ii., 1876, p. 323).

Inflamed Surfaces.—A solution of subacetate of lead is still, perhaps, the most frequently used of all remedies in the external inflammatory conditions for which it was introduced by Goulard, of Montpelier, more than 100 years ago.

In *erysipelas* it proves cooling and astringent, and a good formula for its use is that given by Christison, Murchison, and others (*Medical Times*, i., 1867, p. 523), viz., 4 gr. each of lead acetate and of powdered opium in an ounce of warm water. The meconate of lead is formed, and precipitates, but gives an effective therapeutical result; a more elegant form combines the lead salt with acetic acid and acetate of morphia. Dr. Lawson speaks well of a solution of acetate, 10 to 20 gr. in ½ oz. each of plain water and lime-water, for all kinds of *burns*, *wounds*, and *ulcers* (*Lancet*, ii., 1875). Mr. Freer, from much practical experience, recommends the carbonate of lead with linseed oil (white paint) in preference to the acetate, or indeed to any other application; it has the advantage over nitrate of silver of being painless, and it often relieves very quickly (*Lancet*, i., 1859). It is good not only in erysipelas, but in burns, carbuncles, eczemas, etc., since it excludes air and exerts a sedative effect—it may be applied with a feather, and a fresh coat put on every two hours or so, and left to peel off in a few days. A more elegant mode of using the carbonate is with glycerin, 1 dr. to 4 gr. of the powder, and 1 oz. of cerate; this is useful for erythema.

Conjunctivitis.—Warm lead lotions, with or without opium, are very serviceable in ordinary catarrhal cases, but it is important they should not be ordered if the corneal surface be abraded, or else an opaque white deposit may be left.

Eczema.—In cases of moist discharging eczema, lead lotions are often soothing and sometimes curative; a combination of the liquor plumbi 1 oz., with glycerin ½ oz., and cherry-laurel water 3½ oz., is very good for subacute cases, but may require dilution. Mr. B. Squire gives the pref-

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erence to a *glyceride* of subacetate of lead, in the preparation of which glycerin is used instead of the water of the officinal liquor (*Medical Times*, i., 1876): 1 part of this in 4 of glycerin or of vaseline is a useful strength. Equal parts of the liquor plumbi and glycerin have given me as good results in chronic eczematous conditions, and more especially in mentagra. In some cases, the iodide of lead ointment will be found useful.

Wounds.—Mr. Hutchinson has strongly recommended the continuous use of lead lotions in operative surgery. Within about six hours of any serious amputation he applies over and near the part, compresses soaked in a lotion containing ½ oz. of liquor plumbi, and 1½ oz. of spirit of wine, in a pint of water, and kept constantly moistened every half-hour for several days and nights. This constant attention is essential to success, and is the only troublesome part of the treatment, which seems to prevent inflammation, to have some antiseptic power, and certainly to promote union by first intention—no poisonous symptoms have been observed from it (*Lancet*, i., 1875). Zeissl advocated a similar dressing for bubo, after observing the unfavorable results of routine treatment by incision, etc., as carried out in certain German hospitals; he kept the surface constantly covered with linen soaked in solution of basic acetate of lead, and found that inflammation and suppuration were much controlled, and convalescence hastened (*Medical Times*, i., 1872, p. 521).

Onychia.—Powdered nitrate of lead I have found a remarkably good resource in cases of onychia, and it has quickly benefited when ordinary treatment had failed (Marsh, MacCormac, Scott, etc., *British Medical Journal*, i., 1874). Professor Perizzi was the first to draw attention to this.

Sore Nipples.—Dr. Fordyce Barker speaks highly of the nitrate of lead (10 to 15 gr. in the ounce of glycerin) as an application to sore nipples (*Medical Times*, ii., 1873, p. 503).

Enlarged Glands, etc.—The ointment of lead iodide is often useful in chronic adenitis and splenic enlargements, also in chronic synovitis.

Leucorrhœa, etc.—In cases of purulent and muco-purulent discharge from the vagina, the urethra, the ear, etc., lead lotion is very useful, and may be used at any stage, since, if sufficiently dilute, it does not irritate, like alum and some other astringents. If, however, improvement is not obtained from weak dilutions, the full strength should be tried, and zinc sulphate may be added in the proportion of 1 or 2 gr. to the ounce of lead lotion.

THERAPEUTICAL ACTION (INTERNAL).—*Hemorrhage.*—The acetate of lead has decided power over many forms of internal hemorrhage, and is still in frequent use, though not so much so as formerly. Dr. Elliotson often prescribed it in 2 to 3-gr. doses; Dr. Stokes says "nothing can be more striking than its power to arrest the discharge in chronic *bronchial*

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hemorrhage," and I have more than once verified this. Dr. C. J. B. Williams recommended 3 gr. with opium every hour or half-hour in cases of *hæmoptysis*, taking care to give a daily dose of purgative salts (*Lancet*, i., 1862). In the hemorrhage of *enteric fever*, acetate of lead is often valuable.

In an obstinate case of *hæmaturia* (renal), after failure of tannin, iron, and other remedies, grain doses of lead acetate, with ½ gr. of opium, given every six hours, soon arrested all bleeding; a blue line appeared on the gums within a week of this treatment (Gull: *Lancet*, i., 1866). In *uterine hemorrhage*, acetate of lead with opium is often suitable. Dr. Dewees used it largely in plethoric menorrhagia and in hemorrhage occurring during pregnancy.

Dr. Workman has written to advocate a novel prescription, which theory would scarcely seem to justify, though the practice is said to be advantageous; he gives the acetate in ½ to 1 dr. doses without any opium; this causes diarrhœa, but no other bad symptoms, and produces, he says, the best results in hæmoptysis and also in uterine hemorrhage, and causes contraction of the uterus (*Medical Record*, 1878).

Phthisis—Chronic Bronchitis.—At one time, acetate of lead was thought valuable in consumption, and it may relieve some of the symptoms, such as profuse sweating, expectoration, and diarrhœa, but the cases said to be cured by it were probably of chronic bronchitis, with excessive secretion. M. Beau has, however, written comparatively lately to advocate again the advantages of lead treatment in phthisis, recommending the carbonate in gradually increasing doses (*Lancet*, ii., 1861). He founded his practice upon some cases of phthisis which recovered after working in lead-factories, and concludes that a moderate degree of lead-poisoning is antagonistic to the malady—but such an opinion is not generally accepted. I need scarcely say that other physicians condemn the use of lead salts in phthisis "as worse than useless" (*Medical Times*, i., 1860, p. 435). The truth probably lies between the two extremes, but a decided objection to any continued use of the drug is its impairment of appetite.

Pneumonia.—Under the use of lead acetate, a good proportion of success in the treatment of pneumonia has been reported by Brandes, Strohl, Leudet, and others (*British Medical Journal*, i., 1863).

Aneurism.—Since the observations of Dupuytren, who reported three cases of aortic aneurism relieved by lead acetate (together with small bleedings and rest), this remedy has been tried by many physicians. Dr. Owen Rees reported a case of acute popliteal aneurism (*Lancet*, i., 1865), with thin walls, and no coagula in the sac, which did not improve under pressure, and was thought incurable without operation; on October 29th, 3 gr. of acetate with opium were ordered thrice daily, the diet was not restricted, nor rest enforced: on November 1st, there was a slight blue

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line on the gums: on November 5th, the dose was increased to 5 gr., and this was continued for twenty-six days, when the remedy was stopped on account of colic: aneurismal pulsation had ceased. On December 31st the man was at work, and on January 17th reported cured. This rather striking instance I have not found supported by the results of others, though Dr. A. Clark reports a case of thoracic aneurism in which 2 gr. of acetate with opium were given thrice daily for two months, and the patient got better; he was kept constantly at rest (*Medical Times*, ii., 1867, p. 566). Stillé remarks that the sacculated form of aneurism can only be cured by coagulation of blood in the sac, and in so far as acetate of lead promotes this, it assists a cure, but in the fusiform aneurism, with symmetrical distension, no mere astringent can exert a salutary power. Bellingham objects to the use of lead in any case, and Mr. T. Holmes, who has known aneurism develop during the course of a lead colic, asserts that the acetate is of no real value in the treatment of the malady (*Lancet*, i., 1872). Dr. Bristowe points out that it may help to quiet the circulation, but cannot really coagulate blood within the vessels, otherwise its administration would lead to danger from thrombosis or embolism. From a general review of the evidence at present before us, I should conclude that although individual cases of apparent benefit may be cited, as a rule very little can be expected in aneurism from the use of lead.

Diarrhœa—Dysentery.—Stillé has collected a large amount of evidence, American and foreign, in favor of lead acetate as a remedy in many forms of these disorders. Graves and others have recommended it in cholera. It certainly exerts a powerfully astringent effect, but should not be used without due regard to the elimination of irritating material by previous purgation if necessary. In some cases of obstinate diarrhœa among the ill-fed children of the poor, I have found it exceedingly useful.

PREPARATIONS AND DOSE.—*Plumbi acetas:* dose, ½ to 3 gr. or more. *Pilula plumbi cum opio:* dose, 4 to 8 gr. (1 gr. of opium in 8 gr. of the pill mass). *Plumbi iodidum:* dose, ¼ to 1 gr. *Suppositoria plumbi composita:* (1 gr. of opium and 3 gr. of acetate in each). The following are for external use only:—*Plumbi oxidum; Emplastrum plumbi* (diachylon); *Emplastrum plumbi iodidi; Unguentum plumbi acetatis; Liquor plumbi subacetatis* (Goulard extract); *Liquor plumbi subacetatis dilutus* (Goulard water); *Unguentum plumbi subacetatis comp.* (contains camphor, wax, and oil—better made with vaseline); *Plumbi carbonas; Unguentum plumbi carbonatis; Plumbi nitras.*

[PREPARATIONS, U. S. P.—*Plumbi acetas; Ceratum plumbi acetatis:* solution of subacetate of lead 2½ fluid ounces, white wax 4 troyounces, olive-oil 8 troyounces, camphor 30 gr.; *Linimentum plumbi subacetatis:* olive-oil 3 troyounces, solution of subacetate of lead 2 troyounces; *Liquor plumbi subacetatis; Liquor plumbi subacetatis dilutus;*

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Suppositoria plumbi: acetate of lead 36 gr., oil of theobroma 324 gr.; make 12 suppositories; *Suppositoria plumbi et opii:* acetate of lead 36 gr., extract of opium 6 gr., oil of theobroma 318 gr.; make 12 suppositories; *Plumbi carbonas; Unguentum plumbi carbonatis* (60 gr. in 1 oz.); *Plumbi iodidum; Unguentum plumbi iodidi* (60 gr. in 1 oz.); *Plumbi nitras; Plumbi oxidum; Emplastrum plumbi.*]

POTASSIUM—KALIUM, K,=39.

This metal has not been found native, but its various compounds are very widely diffused. The nitrate occurs in various soils, and the chloride in mines, the tartrate in the juice of the grape and other fruit, and carbonates and chlorides are found in the ashes of all woods and plants; chloride of potassium abounds especially in the seeds of leguminosæ (Berthier). From vegetables this salt passes into the animal organism, and hence the milk and the urine of herbivora contain much more of it than the same secretions of carnivora: the blood-globules and the contractile substance of muscle contain a comparatively large proportion of it.

Characters.—The metal itself is soft and silvery white, so light (sp. gr. .865) that it floats on water, and with such affinity for oxygen that it abstracts that gas from the water, thus setting free hydrogen which ignites and burns with a violet purple flame, characteristic of the presence of potassium. Some liquid devoid of oxygen—like benzine—is therefore required for keeping the metal; if exposed to the air it rapidly oxidizes to potash.

Compounds of Potash.

Potassii iodidum (*v.* vol. i., p. 59). *Potassii bromidum* (*v.* vol. i., p. 97).

LIQUOR POTASSÆ—SOLUTION OF POTASH, KHO,=56.

Preparation.—By adding slaked lime to a boiling solution of about twice its weight of carbonate of potash; carbonate of lime subsides, and the clear solution of potash is transferred by means of a syphon to a bottle, which should be of green glass.

$$K_2CO_3 + CaH_2O_2 = 2KHO + CaCO_3.$$

(The solution would corrode wool or other organic filters, and would dissolve lead in white glass.)

Characters and Tests.—A colorless liquid of acrid taste, and strongly alkaline reaction; sp. gr. 1.058; contains nearly 6 per cent. of caustic potash, or 27 gr. in the fl. oz.; it feels soapy when rubbed between the fingers, on account of its solvent action on the cuticle; it corrodes

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animal and vegetable substances, and forms soluble soaps with oily and fatty bodies. It is liable to contain carbonate of potash, lime, sulphates, chlorides and alumina. The best general test for potash salts in solution is perchloride of platinum, which precipitates a yellow double chloride.

POTASSA CAUSTICA—CAUSTIC POTASH—HYDRATE OF POTASH—POTASSIC HYDRATE, KHO, =56.

PREPARATION.—By rapidly evaporating the *liquor* to dryness in a clean silver or iron vessel, then fusing and pouring into suitable moulds.

CHARACTERS AND TESTS.—Occurs in hard fibrous pencils, which should be white, but are often bluish in color; of peculiar nauseous odor, and acrid taste. It has a strong affinity for water and carbonic acid, and readily deliquesces if exposed to the air: is soluble also in alcohol. Heat is evolved during its solution in water.

POTASSÆ CARBONAS—CARBONATE OF POTASH, K_2CO_3, =188.

PREPARATION.—From the ashes of plants which consist of a soluble carbonate, and insoluble salts of lime, silica, etc. The carbonate is dissolved out by frequent washing with water, which is then evaporated, and the residue fused to a brown stony mass—the crude potashes of commerce (black potash). This is purified by calcination in a furnace, the dull white residue being termed "pearl-ash," and this again is further purified by solution in a small quantity of water, filtering, and evaporating to dryness. The carbonate may also be obtained by heating to redness the bicarbonate.

CHARACTERS AND TESTS.—Occurs in small white opaque crystalline grains, having strong alkaline taste and reaction; it is distinguished from the bicarbonate and from sodium salts by its great affinity for water, for on exposure it soon deliquesces into a thick liquid.

POTASSÆ BICARBONAS—BICARBONATE OF POTASH, $KHCO_3$, =100.

PREPARATION.—By passing carbonic acid gas through a strong solution of carbonate of potash; the stream of gas should be disengaged slowly but continuously for a week: crystals of bicarbonate are gradually deposited.

$$K_2CO_3 + H_2O + CO_2 = 2KHCO_3.$$

CHARACTERS AND TESTS.—These crystals are large, transparent, colorless, rhombic prisms, which are not deliquescent and not caustic; they are soluble in four parts of cold, and less than their own weight of boiling water, insoluble in alcohol: nearly neutral to test paper.

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POTASSÆ ACETAS—ACETATE OF POTASH, $KC_2H_3O_2$, =98.

PREPARATION.—By neutralizing acetic acid with carbonate of potash; the acetic takes the place of carbonic acid, which is liberated with effervescence.

$$K_2CO_3 + 2HC_2H_3O_2 = 2KC_2H_3O_2 + H_2O + CO_2.$$

The liquid is evaporated, and the salt dried, melted, and crystallized.

CHARACTERS AND TESTS.—Occurs in white, smooth, glistening, and generally long pieces, which are soft, fibrous in texture, and unctuous to the touch: neutral in reaction, very deliquescent, and soluble in alcohol, as well as in water.

POTASSÆ CITRAS—CITRATE OF POTASH, $K_3C_6H_5O_7$, =306.

PREPARATION.—By neutralizing carbonate of potash with citric acid; a reaction similar to the last-mentioned occurs, but this acid being tribasic, requires three equivalents of carbonate for saturation.

$$3K_2CO_3 + 2H_3C_6H_5O_7 = 2K_3C_6H_5O_7 + 3H_2O + 3CO_2.$$

CHARACTERS AND TESTS.—Citrate of potash is a white, granular, crystalline powder, deliquescent, soluble in water, insoluble in alcohol. It is charred by hot sulphuric acid, and its solution gives a precipitate with chloride of calcium only when boiled—a test which distinguishes it from tartrate of potash.

POTASSÆ TARTRAS—TARTRATE OF POTASH, $K_2C_4H_4O_6$, =226.

PREPARATION.—By boiling the acid tartrate with carbonate of potash and water, when an equivalent of hydrogen in the acid salt is replaced by one of potassium, and carbonic acid given off.

$$2KHC_4H_4O_6 + K_2CO_3 = 2K_2C_4H_4O_6 + H_2O + CO_2.$$

The liquid is then concentrated to crystallization.

CHARACTERS.—Occurs in small granular crystals, deliquescent, soluble, neutral in reaction, and somewhat bitter in taste.

POTASSÆ TARTRAS ACIDA—ACID TARTRATE OF POTASH—CREAM OF TARTAR, $KHC_4H_4O_6$, =188.

PREPARATION.—Grape-juice contains a large quantity of this salt, which is retained in solution by the saccharine matter. When this latter is converted into alcohol by fermentation, the acid tartrate is gradually deposited inside the wine casks, and is known as "crude tartar," or "argol," and this, when purified by recrystallization, constitutes "cream of tartar," a name originally given to the fine crystals which were "skimmed off" the evaporating liquid.

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CHARACTERS AND TESTS.—Occurs as a gritty white powder, or in fragments of cakes. It is distinguished from the neutral tartrate by its very sparing solubility in water, viz., 1 in 180 parts: in spirit it is insoluble, like other tartrates. It chars on exposure to heat, giving off inflammable gas and an odor of burnt sugar.

POTASSÆ SULPHAS—SULPHATE OF POTASH, K_2SO_4, =174.

PREPARATION.—There is no process directed in the Pharmacopœia, but the salt may be prepared from the residue left in the manufacture of nitric acid, this residue being an impure acid sulphate, which is converted into the neutral salt by treatment with lime, and afterward with carbonate of potash and sulphuric acid.

CHARACTERS AND TESTS.—A very hard crystalline salt, sparingly soluble in cold water; decrepitates on heating: has a bitter, rather nauseous taste.

POTASSA SULPHURATA—SULPHURATED POTASH (HEPAR SULPHURIS).

PREPARATION.—By fusing together carbonate of potassium and sublimed sulphur.

CHARACTERS AND TESTS.—From its liver color, when fresh, it was formerly called "liver of sulphur," but it rapidly absorbs oxygen from the air and becomes green, and ultimately dull white, sulphate of potash being formed. It evolves sulphuretted hydrogen on the addition of any acid.

POTASSÆ NITRAS—NITRATE OF POTASH—NITRE—SALTPETRE, KNO_3, =101.

PREPARATION.—Nitrates occur naturally in many waters, soils, and plants, but are mainly obtained either from certain soils in India by solution in water, or from artificial "nitre beds," *i.e.*, heaps of manure and vegetable refuse, wood ashes and calcareous earth, which are exposed to the action of air and sun. The nitrogen of the organic matter is slowly oxidized into nitric acid, which combines with the bases present (potash, etc.), and the nitrates so formed are removed by washing.

CHARACTERS AND TESTS.—Occurs in white crystalline fragments, or in striated, long, six-sided prisms, which are transparent. It is soluble in water, and has a cooling taste; at a red heat it deflagrates. When fused and cast into round moulds, it is known as "sal prunelle;" abroad, these are often colored purple (like a plum: *prunelle*—a *sloe*).

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POTASSÆ CHLORAS—CHLORATE OF POTASH, $KClO_3$, = 122.5.

PREPARATION.—By passing chlorine gas over a mixture of potash carbonate and excess of slaked lime; chlorinated lime and chlorinated potash are first formed, and the latter is then converted into chlorate of potash on boiling; but the reaction may be simply expressed thus—

$$6Cl_2 + K_2CO_3 + 6CaH_2O_2 = 2KClO_3 + CaCO_3 + 5CaCl_2 + 6H_2O.$$

CHARACTERS AND TESTS.—Chlorate of potash occurs in pearly-white, hard, crystalline plates, which are slightly soluble in water, and have a cooling taste. Rubbed with sulphur, or phosphorus, or tannic acid, or catechu, etc., the salt explodes; treated with sulphuric acid, it becomes red, and gives off vapors of chlorine peroxide.

POTASSÆ PERMANGANAS—PERMANGANATE OF POTASH, $KMnO_4$, = 158.

PREPARATION.—The principal steps of the process are—(1) to prepare manganate of potassium (K_2MnO_4); (2) to convert this into permanganate ($KMnO_4$) by boiling. Black oxide of manganese, caustic potash, and potassic chlorate are fused together, and a dark green mass of manganate of potash obtained.

$$3MnO_2 + 6KHO + KClO_3 = 3K_2MnO_4 + KCl + 3H_2O.$$

This manganate, when boiled, filtered, and acidified with sulphuric acid, yields a purple solution of the permanganate.

$$3K_2MnO_4 + 2H_2O = 2KMnO_4 + 4KHO + MnO_2.$$

The green manganate, when turning into the purple permanganate, undergoes several changes of color, and hence has received the name, "mineral chameleon:" finally, the solution is evaporated, and the crystals purified.

CHARACTERS AND TESTS.—Occurs in dark purple acicular crystals, one of which will impart its color to a large quantity of water. It yields up most of its oxygen (five-eighths) very readily; and if only a little spirit be boiled with its solution, it changes to yellowish brown, on account of its reduction to the state of peroxide. A similar brown stain is left on the hands when washed in it, on account of its oxidation from contact with the organic substance. In distilled water, the purple color may remain two years without change. (Manganese stains are removed by oxalic acid—"salts of lemon.")

POTASSÆ BICHROMAS—BICHROMATE OF POTASH, $K_2Cr_2O_7$, = 295.

PREPARATION.—By roasting chrome iron-ore with a mixture of carbonate of potash and chalk; yellow chromate of potash is formed, and yields the red bichromate when treated with sulphuric acid.

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CHARACTERS AND TESTS.—Occurs in large, red, transparent, four-sided tables, soluble in ten times their weight of water. The solution readily gives up part of its oxygen, and when acidified with sulphuric acid, turns green from reduction of the chromic acid, and formation of green sulphate of chromium.

ABSORPTION AND ELIMINATION.—*Liquor potassæ*, taken on an empty stomach, is quickly absorbed; it then combines, probably, with carbonic acid in the blood, and is eliminated by the kidneys, mainly in combination with sulphuric acid (Parkes: *Medico-Chirurgical Review*, 1853). When taken with food, or in very small doses at any time, it forms with the gastric acid a chloride, and as such is absorbed; its elimination under these conditions is not recognized so readily.

The *carbonates*, when taken in small doses, are absorbed as chlorides; of large doses, the greater part passes out by the kidneys unchanged: a single large dose (2 dr.) is eliminated more quickly than the same amount given in divided doses (Thompson: *Medico-Chirurgical Review*, ii., 1864). The *acetate* and *citrate* are reduced in the system to carbonate, and eliminated as such; the *tartrate* is commonly unchanged. The *chloride*, *chlorate*, and *nitrate* are absorbed very rapidly, and have been detected in the urine, the saliva, etc., within five minutes after being taken.

Much interest attaches to the chemical changes which the *chlorate* undergoes in the system; it was believed to become a chloride, parting with its oxygen to the blood and tissues (Fourcroy)—the proportion even of oxygen furnished was calculated (Garnett). Gubler and some other modern observers also think it possible that a partial reduction of the salt may occur within the body, but it is difficult to reconcile this with the chemical fact of its being found *unchanged* in the urine passed after its administration (Wöhler, 1824), as also in the saliva, milk, tears, bronchial mucus, etc. (Isambert). Rabuteau, taking himself small doses, also found the drug *unchanged* in the secretions, and of one large dose of 5 grammes, recovered 4.873 grammes from the urine within thirty-six hours (*Gazette Méd. de Paris*, 1868). Hence it seems improbable that the chlorate should decompose and give up oxygen at the temperature of the body, and yet there is some clinical evidence of its improving oxygenation in whatever mode this may be effected (*v.* vol. i., p. 19, and vol. ii., p. 282).

When *nitrate* of potash has been taken in large doses (270 gr. in twenty-four hours), the greater part has been found unchanged in the urine—the rest probably passing as sulphate by the intestines (Taylor: *Guy's Reports*, 1863); that a certain amount of potash salt passes off in this manner has been shown by Kramer (*Annales d'Hygiène*, i., 1843).

PHYSIOLOGICAL ACTION.—*Oxidation and Nutrition.*—How far alkalies, as such, contribute to oxidation, has long been a question of interest, and it is one of great practical importance. Organic substances, such as bile and hæmatin, when exposed to air outside the body, certainly oxidize

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more quickly when in contact with potash (Chevreul, 1825): olein, again, is not acted on by ozone alone, but if potash be added, oxidation sets in at once. We know, also, that albumen, dissolved in water, changes but slowly, while the addition of alkali induces immediate oxidation, and in the ordinary test for diabetic sugar, potash deprives of oxygen even a metallic oxide.

Physiological chemists did not fail to trace a similar action within the body. Lehmann and Mialhe taught that alkalies were powerful promoters of systemic oxidation, and augmented the excretion of urea and carbonic acid. Liebig fully adopted the same view, teaching that they promoted the combustion of "respiratory foods," and pointing out that if organic acids (gallic, citric, etc.) were taken alone, they passed off almost wholly unchanged, but if in combination with alkalies, *e.g.*, as citrate of potash, the acid was "burnt off" in the system, and the alkali passed as a carbonate. The experiments of Frerichs illustrated the same point; he gave urate of potash to rabbits, and yet found no uric acid in the urine, for it became changed into oxalic acid and urea, the excretion of the latter being much increased.

Bence Jones concluded that alkalies, though they could not themselves give up oxygen, decidedly assisted oxidation of organic substances within the body by promoting the formation of acids ("Lectures," and *Lancet*, i., 1867, p. 202), and Parkes found, in a series of analyses, that the organic material and sulphuric acid excreted in the urine were markedly increased under the use of liquor potassæ, which acted, he considered, by increasing the oxidation of sulphur and protein tissues; for this effect it had to be given at least eight hours after food (*Medico-Chirurgical Review*, 1853). Similar results did not follow the use of acetate or nitrate of potash in Parkes's experiments, but Dr. Golding Bird reported a considerable increase of urea and other urinary solids in the case of a dog submitted to the action of 3 dr. of the acetate ("On Urinary Deposits"). Dr. Reginald Thompson proved by several series of observations, that the amount of phosphoric acid in urine was increased by the administration of carbonate of potash (*Medico-Chirurgical Review*, ii., 1864).

Besides the cases reported by Dr. Parkes, we have clinical evidence from Dr. Austin Flint of much increase in the urinary solids of a number of patients taking nitrate of potash, and Dr. Basham, observing specially cases of lithic acid diathesis, not only found the urea increased under the use of potash, but oxalic acid appeared as uric acid lessened, and oxalic acid and urea are recognized products of the oxidation of uric acid.

We might almost conclude from the preceding statements that the question as to alkalies increasing oxidation was answered in the affirmative, and yet practical experience shows that some qualifying statement is required, for do we not see marked asthenia, pallor, and anæmia produced in many persons by full doses of alkali, and in all persons by their

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continued use? (so that Trousseau speaks of their doing more harm than the abuse of iodine or mercury); and moreover, is not temperature reduced by salts of potash, so that they are used as anti-pyretics? whereas, if they increased oxidation, the results should be opposite to these. (Dr. Ridge argues that although some amount of alkali promotes oxidation, the "secondary effect" is to retard it—*Medical Times*, ii., 1871.) To advance knowledge in this direction, Rabuteau has recently recorded the results obtained on himself, on Constant (of Smyrna), and on a third person (a woman). Each took 5 to 6 grammes of bicarbonate of soda or potash for five to ten days. The full dose of bicarbonate of potash produced a slight diuretic effect, but 5 grammes none at all; urea was markedly and progressively *diminished*, and depression and anæmia were induced: analogous results were obtained by Ritter, of Nancy; 5 grammes of chlorate equally *diminished* urea (Fouilhoux, Thèse, Paris, 1874), and 10-gramme doses of nitrate acted in a similar manner (Jovitzu).

The explanation of such contradictory results turns largely upon the question of dosage, as with many other medicines. Large quantities, like those last referred to, will pass out unchanged and quickly, and in their passage so far deteriorate the blood-condition and impair the function of the alimentary tract as to induce asthenia and diminish nutrition; hence, evidently Dr. Parkes's supposition that increasing the dose of potash will proportionately increase oxidation cannot be sustained. Small doses, on the other hand, not only help to saponify fatty food, but aid its oxidation, and that of carbonaceous material generally, improve the digestion, and raise the temperature.

Rabuteau himself confirms these statements, and explains these effects of small doses by their change into *chloride* in the stomach, and their acting as chlorides rather than as alkalies; under the influence of 5-gramme doses of chloride of potassium he found the excretion of urea increased by 20 per cent.

That potash salts are essential for the development of the animal tissues is shown by the fact that food which in itself is not sufficiently nutritious, such as over-stewed meat, recovers its properties on the addition of these salts and of a little sodium chloride (Binz); the absence of potash salts seems to be at least one cause of scurvy (Garrod). If, on the other hand, we give meat broth which is very rich in potash salts, without adding any other nutrient, tissue-change becomes so accelerated that animals thus fed die earlier than others kept without food.

Experiments with plants show also how necessary potassium is for cell-nutrition; if it be excluded from their soil and water no growth takes place, for without its presence in the chlorophyll granules no starch is produced.

Souligoux, in a recent treatise, emphasizes the necessity of a due amount of alkali for carrying on all the vital processes, and brings evi-

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dence to show that a large part of its good effect lies in its favoring proper *electrical* reactions and currents within the organism ("Étude sur les Alcalins," 1878, Paris).

Circulatory System.—A certain amount of potash salt is essential, as we have seen, for the proper constitution and action of the corpuscles, and the chloride seems to be the best suited for this purpose (Rabuteau); but the prolonged use of the remedy in any combination has an unfavorable effect. Loffler has reported the results in five of his students who took doses of from 1 to 5 dr. of alkaline carbonates for several days, and then allowed blood to be taken from a vein. It was found to be like "cherry juice" in color and density, the red corpuscles were paler, and the white ones more numerous than normal; there was excess of water and of fatty material, and the clot was less firm and elastic than it ought to be (*Schmidt's Jahrb.*, 1848). A curious illustration of the diminished coagulating power of the blood under the influence of nitrate of potash is furnished by Dr. Stevens, who had occasion to bleed a man who had lately taken an ounce of that salt, and was surprised to find the venous blood red, and not at all coagulable (*Lancet*, ii., 1862, quoted by Dr. Basham). In animals, after injection of nitrate, the result is similar (Rabuteau).

Martin Solon, having analyzed blood drawn from the vein of a robust man suffering from acute rheumatism, and treated by nitre, found the fibrine diminished, though the inflammatory process was still at its height; ten days afterward, when the remedy was no longer being taken, the blood-clot was dense and buffed (*Bulletin de Thérapeutique*, 1843). That the drug cannot, however, be depended upon for antagonizing the effects of disease is shown by the fact of fibrinous deposits having been found on the heart-valves in patients dying during its free administration (*Medical Times*, i., 1863).

Both this salt and the chlorate have the power of rendering venous blood bright red, and much stress was laid upon this change by the early advocates of the direct oxygenation theory (Stevens, O'Shaughnessy: *Lancet*, ii., 1831), but Isambert, after making fresh experiments, asserts that their statements on this point are incorrect (*Gazette Méd.*, 1874), and although the change does occur, it varies with physical conditions, and is dependent rather on altered osmosis than on difference in oxygenation.

Small doses of the potassium salts (excepting the permanganate) cause a fall in the pulse-rate, but a rise in the arterial pressure, probably through the vaso-motor nerves; this effect is usually only temporary (Aubert, Dehn). *Full* doses lower both pulse-rate and blood-pressure. The lowered pressure may, or may not, be followed by a rise according to the dose employed. Parkes found a full dose of *liquor potassæ* render the pulse small and slow, but a copious secretion of urine explained this effect. Under the *nitrate* the pulse-frequency came down in a few days from 76

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to 64 (Rabuteau, p. 229), and the *chlorate*, according to Socquet, of Lyons, has a similar sedative action. Some observers report a *quickened* circulation, especially after venous injection of chlorate (Gubler); Jacobi speaks of this salt congesting the kidney (*Medical Times*, i., 1876), and Osborn of its congesting the brain (*Lancet*, ii., 1859); but such effects must be exceptional. The observations of Black (1839), and of Bouchardat (1844), and the experiments of Podocæpow (Virchow's *Archiv*, Bd. xxxiii., p. 505), of Guttman, Aubert, Dehn, and others agree in assigning to potash salts a distinctively *depressing* effect on the heart-action. Their injection in frogs quickly lessens the force of the blood-current, and finally arrests the heart in diastole: 10 gr. of chloride injected into the jugular vein of the smaller animals cause instant cardiac death, and since the heart-muscle in such cases is found insensitive to electricity (Traube), and since previous section of the vagi has no influence on the result, we conclude that the cardiac arrest is due to a direct paralysis of the muscular substance. This paralysis is commonly preceded by increased activity, but finally it becomes complete, so that the heart-muscle ceases to react to any ordinary stimulus. If, however, the potash chloride be introduced *gradually* into the system through the stomach, then cardiac contractility is not entirely destroyed by it.

The bitartrate of potash has some power of arresting hemorrhage, especially from the kidney (Ramskill and others, Ranking, i., 1867); it possibly lessens congestion by diuresis or purgation. Albuminuria has occurred under the influence of nitrate.

Nervo-Muscular System.—Large doses of potassium salts lower the reflex irritability of certain parts of the spinal cord (Binz), but many observers consider this to be only secondary to depression of the circulation. The fall of temperature adduced is attributed to the same cause. In warm-blooded animals motor power is weakened, probably from a direct alteration in the *chemical* constitution of muscular elements, for *electrical* reaction remains. (On the other hand, Ramskill finds baths of *sulphuret* of potassium to be the most effective stimulant to muscular action during such diseases as wasting palsy—*Medical Times*, ii., 1860.) In healthy men a sense of weight and fatigue is often felt in the limbs after absorption of the more easily diffusible salts, as the nitrate, oxalate, chloride, iodide, or bromide; local anæsthesia of various parts of the body has been described as a result of drachm doses of bicarbonate (*British Medical Journal*, ii., 1876). There seems, however, to be some idiosyncrasy with regard to such effects, and although full doses usually depress the nerve-functions, Dr. Prout refers to pronounced nerve-excitement, and even convulsion in some cases, as connected with an excess of alkali, and the chlorate of potash is said to have caused headache and cerebral congestion (*v.* p. 272). Isambert considered it a nervine sedative, but "this action was not evident in healthy persons" (*Medical Times*, ii.,

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1856). Rabuteau finds the "perchlorate" to produce giddiness and other symptoms like those of quinine. Liquor potassæ has been used to quiet the spasms of tetanus (*Lancet*, i., 1861).

Dr. Thompson traces the nerve-depression commonly caused by alkalies to an increased excretion of phosphoric acid under their use (*v.* p. 269).

Glandular System—Mucous Membranes.—Dilute alkaline solutions taken into the stomach *before* meals augment the secretion of gastric juice (Blondlot, C. Bernard), for if digestion is to continue, fresh secretion must occur to compensate for what is neutralized; also the chlorides that are formed augment the secretion (Rabuteau). "They favor the outward osmosis of those constituents of the blood from which the acid of the stomach is elaborated" (Bartholow). But alkalies given in too large or too concentrated a dose arrest the secretion, and if given soon *after* a meal prevent even a normal amount of acidity. Dr. Ringer formulates a general proposition thus:—"Alkalies applied to the orifices of glands with acid secretions increase their secreting power, while alkalies applied in a corresponding way to glands with alkaline secretion lessen or check this secretion;" and I think that, as a general rule, and with due regard to the strength of solution, this may be held true.

The increased secretion of saliva caused by direct application of alkalies is thick, whitish, and cloudy; it is not large in amount, and there is some doubt as to whether it is true secretion or (as Kühne thinks) the result of a rapid degeneration of the gland. A similar fluid results from irritation of the sympathetic nerves of the submaxillary gland, and hence the alkali has been thought to act through the sympathetic. The chlorate of potash sometimes acts so as to produce a degree of salivation.

Under the influence of alkalies taken internally, the bile and pancreatic juice are increased in amount, and rendered more fluid. The sulphate of potash given internally has special power in this direction (Rutherford), more than magnesia. The bronchial secretions are also increased and fluidified by alkalies, and the movements of ciliated epithelium are rendered more active by them.

Secretion from the intestinal glands is augmented, especially by full doses of the potash salts of mineral acids: 2 or 3 dr., *e.g.*, of the sulphate cause watery purging; larger quantities sometimes irritate much: ½-oz. doses have been used in France as abortifacient with serious effects (Mowbray), and 2 oz. have caused death (Taylor).

The nitrate in small doses is absorbed and produces some constipation, but in full doses and well diluted causes diarrhœa (Martin Solon, 1843). Orfila reported violent irritation of the mucous membrane from its use, and an ounce has caused death with irritant symptoms and depression, though this is exceptional. The experiments of Rognetta indicated only a moderate degree of congestion—no inflammation; and ounce doses, when well diluted, have been given medicinally without serious result.

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The chlorate may also irritate mucous membranes, and in large doses has sometimes, though rarely, caused death through this effect, *e.g.*, in a patient with phthisis, who took 300 gr. daily for four days, and in the case of Dr. Fountain, who unfortunately took an ounce in order to prove his conviction of its innocent character (Stillé).

The bichromate in small doses increases all the secretions, in large doses acts as an irritant poison, and induces suppression of urine.

The urine is often markedly increased in quantity by liquor potassæ (Parkes), by the bicarbonate and the chlorate, but still more by the bitartrate, nitrate, acetate, and citrate; the increase is not always decided, unless the urine is rendered alkaline. There is a marked difference in different compounds as to their production of alkalinity: thus, a single dose of 40 gr. of acetate alkalinized the urine in a few hours, and then was not all changed, but of the bicarbonate several drachm doses were required. In febrile diseases, salines, such as nitrate of potash, may cause at first marked lessening of excretion, afterward increase (Parkes: *Medical Times*, i., 1855). In cases of irritant poisoning by the potash salts of the mineral acids, suppression of urine has occurred, probably reflex in character.

Synergists and Antagonists.—The other alkalies are allied in chemical action to the salts of potash, and acids are the chemical antagonists. Gubler suggests that soda is antagonistic to potash (dynamically) in its action on the blood and on respiratory combustion, because potash only, not soda, is contained normally in corpuscles, and under certain conditions may be replaced by the latter when given in full doses.

Therapeutical Action (External).—Caustic potash has been used in surgery for the same purpose as other powerful caustics, and has the special characteristics of being deliquescent and of dissolving and deeply penetrating the tissues; parts near the seat of its application should therefore be protected by plaster, or by oil, and the cauterized place should be sponged with dilute vinegar to prevent undue action. The slough caused by it is leathery, soft, dark-colored, and moist, not dry like that of nitrate of silver: it separates after a variable time, according to its thickness.

Issues—Abscess—Bubo, etc.—For the purpose of making an issue, or of opening a large collection of matter, such as a chronic or "cold" abscess, caustic potash was formerly often, and for the latter purpose is still occasionally, used. Macnamara has found better results from it than from the knife in opening bubo (Ranking, i., 1872), and others recommend it in carbuncle. It causes pain but no hemorrhage, and makes a good free opening for the escape of the slough.

Caries—Necrosis, etc.—Caustic potash and concentrated solutions of the carbonate have been recommended in these conditions, but sulphuric acid is to be preferred (*Medical Times*, ii., 1860; *Lancet*, i., 1870). In ununited fracture, potash has been used to vivify the ends of the bones.

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Varix—Nævus.—It is said to have the power of obliterating the trunk of a varicose vein (Bonnet), and also of destroying superficial nævi (Wardrop); but the application is painful, and is apt to leave a very evident cicatrix. Powdered nitrate of potash kept in contact with the nævus, is said to give a better result in slight cases.

In *Hospital Gangrene*, the part may be first dressed with the solid caustic, and afterward with a lotion containing it in gradually diminishing proportion—400 cases are said to have been treated successfully by this means (Restelle: *British and Foreign Review*, October, 1850). Lotions of permanganate and of chlorate are also valuable.

Strumous Ulceration.—In strumous ulceration of superficial and indolent character, with livid undermined edges, and affecting extensive surfaces on the trunk or extremities, caustic potash lightly applied to the margin often stimulates to satisfactory healing.

Lupus.—For cases of ulcerative lupus in which the strumous character is most marked, caustic potash is sometimes a good agent; we do not apply it generally for lupus about the face, because of the unsightly cicatrix which is apt to follow its use; but in Vienna it is in frequent request, and is found to succeed when other remedies have failed.

Epithelioma.—The disadvantage of the deliquescent character of potash may be obviated, and its efficacy rather increased by combination with caustic lime, two parts of the latter to one of the former constituting "Vienna paste;" it should be kept dry, and moistened only with a little spirit as required. Epithelioma affecting the lip has been sometimes cured by successive applications of this caustic, but it is painful and tedious. The *chlorate*, given internally and applied locally, has also been said to arrest and cure epithelioma, and certain Paris surgeons especially have reported well of the local use of concentrated solutions. I have observed several cases treated in this manner, but without substantial benefit.

Uterine Ulceration.—Pure caustic potash has been applied to ulcerations and hyperplasiæ of the cervix uteri, and although disastrous results, such as contraction and cicatrix have occasionally followed, it may be of decided service, in skilled hands, not only for irregular ulcerative conditions, but also in chronic cervicitis with induration (areolar hyperplasia); in such cases it may be applied about every ten days for several times, and free injections of vinegar and water should be used afterward. Dr. Henry Bennet recommended it or the lime compound "as a last resource," and the Vienna paste is sometimes serviceable. French surgeons use the same remedy, with an additional quantity of lime, carefully prepared in lead or iron tubes (caustic of Filhos, of Robiquet).

Primary Syphilitic Ulcers, Warts, etc., have been sometimes destroyed by caustic potash. The bichromate is very useful for this purpose.

Urethral Stricture has been treated by the application of caustic potash to the affected part, and in some cases of cartilaginous hardness, and

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of unusual irritability, it apparently proved useful—with due precautions—but the majority of modern surgeons rightly, I think, object to any direct caustic application in such cases.

Leucorrhœa—Gonorrhœa.—In the former affection, when the discharge is profuse and strongly alkaline, and either transparent or white, coming probably from the glands of the cervix uteri, a weak alkaline injection (1 dr. of bicarbonate to the pint), thoroughly applied, will often relieve; but injections of chlorate (2 dr. to the pint) act better, especially if the discharge be at all purulent (*American Medico-Chirurgical Review*, November, 1858). The permanganate should be used if there be a disagreeable odor.

In gonorrhœa, injections of the permanganate (1 to 5 gr. to the ounce) have been highly praised, especially in the second stage (*Medical Times*, ii., 1862). In many cases they certainly act well, but care should be taken to begin with a weak solution, for I have known pain and irritation produced by such injections. Besides the local applications of potash salts, the scalding and burning pain in micturition may be much relieved by the bicarbonate, or perhaps better by the acetate and nitrate, given internally with mucilage, etc.; it is said even that the attack may be cured by them (*Lancet*, ii., 1850, p. 507). In chronic cystitis with fetid urine, injections containing chlorate (4 gr. to 1 oz.) are recommended by Braxton Hicks.

In-growing Nail, etc.—This troublesome affection may be well treated by means of dilute liquor potassæ (2 dr. to the ounce of water) constantly applied on lint, between the nail and the soft tissues, so as to thin the nail and render it flexible, when it can be rubbed or pared away (Norton: *Lancet*, i., 1869).

Unhealthy Wounds.—Several compounds of potash have valuable disinfectant and also alterative properties, especially the permanganate (Condy's fluid) and the chlorate, and when used in the form of lotion prove of the greatest service in removing fœtor and promoting healthy action. For the *bites of rabid animals* its penetrating and alkaline powers render liquor potassæ valuable; in *snake-bite* especially it should be applied locally as well as given internally; it fluidifies the blood and promotes bleeding from the bitten part (*v.* p. 285).

Stomatitis—Diphtheria.—In aphthous conditions and unhealthy ulcerations about the gums, palate, or tonsils, gargles containing the chlorate or permanganate are very good (*v.* p. 283). In diphtheria, both these salts have proved of great service (Ranking, i., 1865). A useful proportion of the permanganate for local application is about 10 gr. to the pint of water.

Eczema.—A weak lotion of bicarbonate of potash (or of soda), 30 to 60 gr. in the pint, will often relieve the early discharging stages of eczema, and a stronger application (caustic potash, 5 to 20 gr. in the ounce)

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is a useful stimulant to patches in the chronic stage; although painful, it markedly relieves the itching, which is often worse than pain. The German school especially have reduced to a system the application of potash, in the form of their sapo viridis ("schmeier-seife"), which is made by boiling some animal oil with potash and its carbonate; it forms a soft amber-green compound, more elegant than our "soft soap." Of this a general bath is prepared with 1 dr. to the pint, a second strength (1 dr. to ½ oz. of water) is used for infiltrated subacute patches, and a third (1 dr. to 2 dr. of water) acts as a caustic for very chronic cases; besides these the German codex contains a "spirit of soap," etc. The solution of selected strength should be thoroughly brushed in, and the irritation quickly relieved by a stream of cold water. The use of such remedies is painful, and causes profuse serous secretion from the part; before commencing a course of them, vascular irritation should be subdued by cold water, etc., and afterward it will be found desirable to use some emollient, such as glycerin or oil, otherwise the skin becomes harsh and dry. There can be no doubt that in some chronic forms, and especially in chronic eczema of the scalp, the soft-soap treatment gives remarkably good results (*Medical Times*, i., 1860.)

Sebaceous Disorder—Acne, etc.—In cases of greasy skin and of obstructed follicles, soft soap is a good remedy. In the former it cleanses and tends to lessen secretion; in the latter it dissolves obstruction, but it should be used cautiously if much inflammation be present. Alkaline drops or injections are useful for softening and evacuating hardened cerumen in the meatus.

Scabies—Ringworm.—Preparations of potash (soft soap, etc.) are indirectly useful in parasitic disorders by softening the epidermis and removing secretion, and thus allowing the more direct contact of sulphur or similar remedies, hence the carbonate is a frequent ingredient in pomades for scabies. The sulphocyanide of potassium is a direct parasiticide, and has been commended by Dr. Gee in ringworm (½ oz. in 8 oz. of water).

Psoriasis.—The diffused forms of this disease may be much relieved by alkaline baths (potash and soda carbonates together, of each 3 oz. in the bath), and thickly accumulated scales may be removed by frictions with soft soap. Oil of cade may be usefully combined with the same remedy (soft soap, rectified spirit, oil of cade, equal parts). Hebra applies to severe cases a daily friction with soft soap for many days, not using a bath during the course, but keeping the patient in blankets. This is, however, a painful process, on account of the great tension of skin induced whenever strong potash applications are made to the general surface.

Lichen—Urticaria, etc.—Weak solutions of potash salts or liquor potassæ relieve the itching and irritation of these disorders, also of pruritus,

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and to some extent of pruritus vulvæ. A lotion made by boiling ½ oz. of potassa sulphurata in 1 pint of water, is very useful.

Rheumatism, etc.—The carbonate of potash, dissolved in a bath of warm water, is often useful to relieve pain in the joints, and irritable eruptions in rheumatic and gouty subjects. The sulphuret of potash, on the other hand, furnishes a bath which stimulates especially the muscular system, and has proved useful in plumbism, in locomotor ataxy, and other forms of paralysis; it has the distinctive properties of sulphur. The silicate of potash, or "liquid glass," applied on saturated bandages, makes an excellent splint for fractures (Darby: *Medical Times*, ii., 1870).

THERAPEUTICAL ACTION (INTERNAL).—*Dyspepsia.*—In cases of irritative dyspepsia, especially when occurring in stout and rheumatic or gouty persons, and marked by red tongue, acid eructations, or pyrosis, with nausea and discomfort after meals, the liquor potassæ or bicarbonate of potash, taken at that time (*after* meals), often gives relief; in gouty cases, and when the urine is loaded, they are to be preferred to soda. In cases of atonic dyspepsia, however, with pale coated tongue and much weight after food, small doses of alkali are best given *before* a meal, and if continued for some time should be combined with a bitter infusion. In cases of "biliousness," with yellowish complexion and conjunctivæ, headache, nausea, etc., and even in actual catarrhal jaundice, salts of potash are good adjuvants (Golding Bird, Bartholow). Dr. Todd recommended the sulphuret (10 gr.) when the "mucous follicles were implicated."

In *vomiting* connected with the condition just described, or with other functional or even organic gastric disorder, or occurring at the commencement of inflammatory fevers, the bicarbonate of potash is advantageously given in effervescence with citric acid.

Acid Poisoning.—In cases of poisoning by the mineral acids, bicarbonate of potash may be employed not only to neutralize the acid, but as an emetic, by giving first a large dose of the alkali, and a suitable quantity of citric acid some minutes afterward. The amount of carbonic acid evolved distends the stomach so as to assist discharge of its contents.

Lithiasis—Calculus.—In cases of excessive secretion of uric acid, potash salts are useful by assisting oxidation of the acid to some extent, and also by furnishing a base with which the acid is readily eliminated in a soluble form; they should be considered, however, rather palliative than curative, and attention should be equally directed to diet and hygiene during their use.

The continued administration of potash had, at one time, much reputation in the treatment of uric acid calculus, and Dr. William Roberts (Manchester) has shown, by careful experiments, that benefit may be ex-

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pected from it under certain conditions. It is specially adapted for renal calculi which cannot be reached in any other way, and for small vesical calculi consisting either of uric acid or of cystine. The acetate and citrate of potash are the best to use, and in order to secure a sufficient and continuous alkalescence of the urine, 30 gr. for children, 40 gr. for adults, of either salt must be taken at intervals of about three hours. This quantity will give to the urine an alkalinity equal to 3 or 4 gr. of carbonate in the pint, which may be kept up for several weeks without injury to the general health, but the urine must be frequently examined, and if it become ammoniacal the treatment should be omitted.

As an illustration of its occasional value may be cited the case of the Rev. V. Harcourt, who, at the age of eighty, continued it for three months, rendering the urine alkaline to the extent of 20 to 25 gr. per pint, with relief to many painful symptoms, and with much advantage (*Medical Times*, ii., 1869). For phosphatic calculi, potash is, of course, unsuitable.

Skin Disease.—Several forms of cutaneous disease are connected with a gouty or rheumatic diathesis, especially forms of eczema and psoriasis; in such cases the urine is often scanty and loaded, and then alkaline diuretics are of service. Mr. Easton has shown the advantages of the acetate (*Edinburgh Monthly Journal*, May, 1850); the liquor potassæ is also given successfully.

Acute Rheumatism.—Up to comparatively recent times, alkaline treatment, by potash especially, was accepted as the best for rheumatic fever. Among its principal supporters, Dr. Fuller claimed that it would prevent cardiac lesions, for such lesions did not occur in any of a large number of cases thoroughly brought under the influence of alkalies (*Lancet*, ii., 1862). He argued that these remedies not simply neutralized abnormal acidity, but restored normal alkaline conditions, maintained fibrine soluble, exerted a sedative influence on the circulation, and favored complete metamorphosis of tissue; he pointed out, also, that for a fair trial correct diagnosis was essential, and that true rheumatism should not be confounded with the gonorrhœal affection, with rheumatic gout, pyæmia, etc., and such a mistake would account for failures; he approved of a compound prescription—thus, ℞. Liq. ammon. acetat. ℥ ij., sodæ bicarb. ʒ iss., potas. acetat. ʒ ss., with citric acid in effervescence.

Sir Thomas Watson recommended liquor potassæ, and Dr. Parkes made use of it (*Medico-Chirurgical Review*, 1864), but it is not really so suitable as the neutral salts. Todd preferred the bicarbonate or acetate in ½-dr. doses every three hours (Ranking, i., 1869). Dickinson has written in favor of the same method, and Golding Bird in favor of the acetate specially, while Dr. Basham was a constant advocate of the nitrate (*Lancet*, 1848, and ii., 1862); he used large doses, from 1 to 3 oz. daily, in 4 pints of barley water. Dr. Wade found the best results from a com-

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bination of these two salts in moderate doses, 15 to 20 gr. of acetate with 8 to 10 of nitrate, and other observers have corroborated his experience (Fleischman: *Lancet*, i., 1869, etc.). On the other hand, Dr. Sutton concluded that none of these remedies could influence the course of rheumatic fever, or prevent heart-complications, though they might allay pain ("Medico-Chirurgical Transactions," vol. lii.). Dr. Ringer, from his own observation, came to a similar conclusion, while Dr. Ridge and others have argued that they are injurious (*Medical Times*, ii., 1871). No doubt the continued use of large doses may induce depressing anæmia, and consequent tedious convalescence, and now that the salicylates and other remedies are better known, we are not so dependent on alkaline medication; it must, however, be held a valuable resource in cases marked by high degree of acidity and loaded urine, and its judicious use may greatly relieve. In my own practice I commonly combine iodide of potassium with bicarbonate in effervescence.

Ague.—Nitrate of potash has been given successfully in ague—10 gr. every two or three hours (in brandy); it increases the secretions, notably the perspiration and urine, and is said to be as sure a specific as quinine, leaving even less tendency to relapse! (Ranking, i., 1869).

Specific Fevers.—Alkalies, especially in effervescence, greatly relieve the thirst and other distressing symptoms in various fevers, and they promote elimination by the skin and the kidneys, etc. The chlorate has been recommended in *enteric* fever by Chomel, but has not been largely given; in *scarlet* fever, I, with others, have found it of much advantage (Watson, Copland); even in *yellow* fever, in the later stages, it is said to do good (*Medical Times*, i., 1875).

Diphtheria.—Chlorate of potash in full doses, either alone or combined with iodide, has seemed very useful to many observers (Squire, Hillier, Perrin, Henoch, Vogel). I quite agree with them; I have for twenty years used it more or less with advantage. In America, it is commonly given with chloride of ammonium. Recently Dr. Ciattaglia (Rome) has recorded his very successful results with doses of 10 to 15 grammes daily; but in addition he thoroughly applied to the affected part a wash of chloral—1 dr. in 5 of glycerin (*Lancet*, i., 1876).

The permanganate of potash has also proved useful in diphtheria, as well internally as locally (Copland: *Lancet*, i., 1863, p. 151, and Ranking, i., 1865, p. 55). I can add my testimony to its value, though it is right to recognize the statements of Dr. H. C. Wood, that he "has never seen the chlorate do a particle of good in such maladies as scarlet fever, diphtheria, etc.," and with regard to the permanganate, "as immediate decomposition of it must occur in the stomach, the absurdity of its internal use needs only to be pointed out" ("Elements of Therapeutics," 473—586).

Croup.—Liquor potassæ has been used in croup both locally and in-

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ternally. Certainly it will dissolve fibrinous membrane outside the body, and to some, but not to a great, extent may be available in the form of spray (½ or 1 dr. to 1 oz. of water). It has been compared to mercury in its constitutional effect of fluidifying secretion and of promoting absorption, but it acts too slowly to be depended upon for so acute a malady as croup. Iodide of potassium is more effective, and the acetate of potash seems to have sometimes acted well. The bichromate I have occasionally used locally and internally, with excellent effect, in true membranous croup.

Pneumonia.—The nitrate of potash is said to be valuable in the early stages (*Dublin Quarterly Journal*, July, 1873), but as Dr. Jones, who commends it, used also antimony and ipecacuanha, we cannot verify its precise effects.

Bronchitis—Catarrh.—When expectoration is scanty, viscid, and brought up with difficulty, either in early or later stages of bronchitis, alkalies often relieve, and may be taken with other expectorants. The liquor potassæ in doses of 10 to 15 min. is one of the most suitable forms: the nitrate is also useful, and is commonly combined with Dover's powder, or with antimony and tinct. camph. co. (Graves: "Clinical Lectures"). Laborde has found the chlorate very serviceable, both in acute and chronic catarrhal bronchitis: it modifies and dilutes the expectoration, which gradually lessens in amount; the respiratory sounds become normal, the cough is relieved, and appetite improved (*Bulletin*, October, 1864). In ordinary catarrh I have found the chlorate a very good remedy; it is recommended also by Dr. Sedgwick (*British Medical Journal*, i., 1873).

Asthma.—The inhalation of fumes of "nitre paper" is often valuable in this malady, and I, with others, strongly recommend it, especially for spasmodic asthma, though it is often available also in the bronchitic form, if congestion be not very acute. The paper may be made with thick blotting-paper, saturating it in a hot solution of nitrate of potash (4 oz. to ½ pint), then drying and dividing it as required. In some cases a little of this is sufficient, and a less strength of solution is desirable, but in others relief is not obtained till the room is filled with the vapor (*Times*, i., 1874, p. 64). Dr. Murrell has recently reported much relief from thick strong papers covered with crystals of nitrate or chlorate; when lighted they give out "dense volumes of smoke" (*British Medical Journal*, i., 1881). Sometimes, however, especially if there be extensive or active congestion, such treatment proves irritant, and its first use therefore requires watching.

Pertussis.—The carbonate of potash was at one time in good repute in the treatment of whooping-cough, but we cannot expect more from it than the thinning of tracheal and bronchial secretion, and a slight sedative effect on the mucous membrane. The acetate has been especially recommended (*Practitioner*, vol. ii.), also the sulphuret; the latter is giv-

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en in doses of 1 gr. per year up to four years, after that age in the proportion of ½ gr. per year. It is important that its solution should be freshly prepared: it is rather nauseous, and acts sometimes as an emetic, but if continued for four or five days will usually do good (Ranking, i., 1869, p. 65).

Phthisis.—The value of chlorate of potash in phthisis has been much disputed: by some it has been esteemed a specific, and though it really cannot be called so, it has the power of relieving at least some of the symptoms. Dr. Fountain introduced it with the hypothesis that it gave up oxygen to the blood (*v.* Physiological Action), and seems to have found benefit from the salt, not only in consumption, but in various disorders with impeded respiration (*Medical Times*, ii., 1859, *American Journal*, 1860).[1] Dr. Harkin records that in the first or second stages of phthisis doses of 5 to 20 gr. improved color and strength, and diminished cough and diarrhœa (*Dublin Quarterly*, November, 1861). Dr. Symonds considered it of service in promoting the healing of vomicæ (*British Medical Journal*, i., 1868), and Spender, pointing out that full doses may readily be given, because of its great solubility in boiling water, "regrets that its value in phthisis is not better known" (*British and Foreign Review*, i., 1872). On the other hand, Dr. Flint's observations satisfied him of benefit from the drug in only one out of fourteen cases, mostly advanced (*American Quarterly Review and Medical Times*, ii., 1861). Dr. Cotton could trace no definite effects to it, though it seemed to improve the vigor of cachectic individuals generally. I have myself known the carbonate as well as the chlorate relieve pleuritic stitches, diminish profuse purulent expectoration, and check copious perspiration.

Chronic Hoarseness—Aphonia.—In these conditions, whether connected with chronic chest-disorder (not laryngeal phthisis) or with overexertion in talking or singing, I have frequently prescribed from 5 to 15 min. of liquor potassæ with advantage; in fact this simple remedy, given every four hours for a few days, has quickly relieved and sometimes quite cured the symptoms.

Struma—Asthenia.—Many observers agree in attributing benefit to the chlorate in strumous asthenic conditions, more or less allied to phthisis. Dr. Harkin used it in all forms of scrofulous glandular ulcerations. Mr. Weeden Cooke praised it in "scrofula," and in the generally impaired condition which follows exanthematous disease (*Lancet*, ii., 1869). It has also acted well in improving the general state during pregnancy, and even in preventing the recurrence of abortion (*Edinburgh Medical Journal*, 1866). The early reputation of potash in struma was founded

[1] Mr. Whymper has recently reported its good effects in relieving headache, and other symptoms induced by highly rarefied air, at an altitude, *e.g.*, of 16,500 feet on Chimborazo; it was recommended to him by Dr. Marcet.

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mainly on the success of Brandish with liquor potassæ, but good air and hygiene were essential elements in his cures. This medicine will sometimes induce the absorption of glandular tumors, but cannot be considered curative of the constitutional taint; it is now practically replaced by iodide of iron and cod-liver oil.

Suppuration—Ulceration of Mouth.—In cases of suppuration, such as carbuncle or continued eruption of boils, or discharging wounded surfaces, also in sloughing or gangrene, the chlorate and permanganate have been found useful internally as well as locally, but it is especially in ulceration about the mouth, the gums, and the fauces that chlorate of potash is most valuable. Mr. Hutchinson has recorded many cases occurring in unhealthy children, and very obstinate until this remedy was given in full doses of from 10 to 30 gr. (*Medical Times*, ii., 1856). Mr. Hunt introduced it as a specific in ulcerative and gangrenous stomatitis ("Medico-Chirurgical Transactions," xxvi.), and I consider it a most valuable remedy when used internally and locally in these affections. In relaxed sore throat and catarrhal pharyngitis the chlorate is often serviceable, and is commonly prescribed in the form of lozenge.

In *mercurial stomatitis* it has proved useful (Herpin, Hutchinson, etc.), and Ricord administered it with mercury to obviate injurious effects from the latter. Sir T. Watson quotes a formula containing the chlorate 10 gr., with an equal quantity of sulphur, as "almost a specific," but my own experience is rather that of Bartholow and some other observers, viz., that the chlorate does not give, in mercurial maladies, the same good results as in ordinary stomatitis.

Diarrhœa.—The chlorate of potash has been recommended in dysentery, and even in inflammatory diarrhœa (Amisy: *Lancet*, ii., 1872, p. 300). Marotti considers the acetate valuable in gastro-intestinal disorder connected with chronic catarrhal conditions and increased secretion of mucus in the alimentary canal, and marked by coated tongue and anorexia (*Practitioner*, vol. ii.), but I think we have more dependable remedies. I should rather avoid it in acute conditions of this kind, but in the form connected with advanced stages of chronic nerve-disorder and cachexia, or "vaso-paralytic" diarrhœa, its use is more indicated. The chlorate is an ingredient in the "saline treatment" of cholera.

Constipation.—The sulphate of potash acts as a mild aperient, and is suitable for cases of dyspepsia with deficient biliary secretion, or hemorrhoids; it is often combined with rhubarb, especially for children (West, Hillier). Dr. Dickinson recommends it in doses of 10 to 20 gr. as a good laxative in albuminuria (*Lancet*, i., 1876, p. 628); in larger doses it is apt to cause griping. The acid tartrate is also used as an aperient, especially in cases of hemorrhoids and of dropsy, since it produces a copious watery secretion into the intestinal canal, but it should be combined with some more active agent to secure efficient expulsive effect; thus it is ordered

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with sulphur in the confectio sulphuris, and with jalap in the pulvis jalapæ compositus.

Purpura—Scorbutus—Hemorrhage.—In purpura simplex, 10-gr. doses of nitrate of potash have been sometimes useful, and even in hemorrhagic purpura the same remedy in large doses (10 to 60 gr.) has been recommended (Carlyon). The advantage of potash salts in true scurvy is not clear, but for the special ulceration of the gums, the chlorate is certainly good (*Lancet*, ii., 1860, etc.). Both the nitrate and the tartrate are of service in the treatment of capillary hemorrhage; the former has been used, especially in hæmoptysis accompanied with febrile excitment (Gibbon), and the latter in hemorrhage from the kidney, bladder, and rectum. Half-drachm doses of the acid tartrate quickly arrested a hemorrhage connected with a malignant growth of the bladder, and 2 dr. is an efficient dose for relieving the loss of blood from piles (Ramskill: *British Medical Journal*, i., 1867).

Cirrhosis of the Liver.—The acid tartrate of potash is said to be "of singular value in alcoholic cirrhosis" (Gull: *Lancet*, i., 1866, p. 6).

Obesity.—There are on record some remarkable cases in which the use of potash salts, and especially of liquor potassæ, has reduced the amount of fat deposited, but these remedies are by no means always effective for this purpose, nor should they be employed without real necessity and due care, for fear of inducing a spanæmic condition. In a case of *local* excessive deposit of fat round the neck of a girl, which was very unsightly, and for which no available treatment could be at first suggested, the use of 15 to 20 min. doses of liquor potassæ ter die, led to marked improvement, and so quickly as to be clearly traceable to the remedy (*Lancet*, i., 1873). In some other cases of fatty tumor, liquor potassæ has also been given with success as regards diminution of the growth.

Diabetes.—The use of alkalies in this malady was at one time largely adopted, in the hope that their property of assisting oxidation would be of direct service, but this hope has been in the main disappointed. The permanganate especially was recommended by Sampson (*Lancet*, i., 1853), and also by Ramskill (*Medical Times*, ii., 1867), but has not proved reliable (Bence Jones, Basham, and others): it seems, however, to have the power of relieving the intense thirst of the malady. The compound alkaline waters of Vichy, Carlsbad, etc., really ameliorate many cases (*v.* vol. i., p. 161). The nitrate, chlorate, and tartrate are also serviceable in polydipsia, and are given dissolved in water or lemonade: the citrate in effervescence may give much temporary relief.

Albuminuria—Dropsy.—The use of alkaline diuretics is advantageous in the early stages of this malady, the citrate of potash or the acetate being the most suitable; they are presumed to act directly on the kidney, washing away *débris* and epithelium, which obstruct the tubules. In later stages, when dropsy is present, and indeed in all forms of dropsy,

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20-gr. doses of the acetate, or half that quantity of nitrate, given in conjunction with digitalis, squill, or other vegetable diuretics, often secure a copious secretion from the kidneys.

Cyanosis.—Although, as before remarked, the theory of oxidation of the blood by means of chlorate of potash cannot be scientifically maintained, yet I have certainly seen benefit from that salt in cases of congenital cyanosis: the color and the temperature have both improved under its continued use. Dr. Balthazer Foster has recorded two remarkable cases, in which he obtained similar results ("Clinical Medicine"). Mr. Harding found it (the chlorate) useful "in cases with lividity, and coldness of lips and extremities, and symptoms of obstructed circulation" (*Medical Times*, ii., 1861), and Dr. Fountain and others have had the same experience.

Tetanus—Chorea.—The power of potash to alter and diminish the contractility of muscular tissue, furnishes some theoretical ground for an old method of treatment of tetanus by means of potash-baths, and the internal administration of the carbonate, "the method of Stütz" (Husemann): practically, this is not often employed, but some cases in which it was successful may be found recorded (*Lancet*, i., 1861). In chorea, also, baths of the same kind have been found beneficial by G. Sée and by Hillier. The internal administration of potash may be desirable, for a time, at least, in cases with rheumatic taint, but must not be pushed to the production of spanæmia.

Blood-Poisoning—Pyæmia.—The influence of potash upon oxidation, and upon the blood-condition, have led to its employment in cases of absorption of poisonous material.

Savory has found it of distinct value, not in acute, but in chronic pyæmia (*Lancet*, i., 1867, p. 202), and Sir James Paget records the disappearance of a chronic pyæmic abscess under the use of liquor potassæ (*St. Bartholomew's Hospital Reports*, vol. i.).

Snake-bite.—Dr. Shortt, the eminent ophiologist of Madras, has recorded indisputable evidence of its value when quickly and largely used after the bite of venomous snakes. He gives it in several ways in order to saturate the blood as soon as possible: thus internally, 20 min. are ordered with 1 oz. of brandy and ½ oz. of water; 1 dr. is injected into the veins every hour, and general and local bathing with a strong solution (4 oz. to the bath) is constantly practised (*Medical Times*, ii., 1873).[1]

Syphilis.—By those who decry or discourage the use of mercury in syphilis, the chlorate of potash is much depended upon as a substitute, especially in infantile forms of the disorder (Drysdale: *Dublin Press*,

[1] M. de Lacerda has recently reported that intravenous injection of a 1 per cent. solution of permanganate, soon after an injection of snake venom, has proved antidotal in dogs (October, 1881).

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December, 1862). I believe that it may contribute to the healing of ulceration in this as in other cachexiæ, but I cannot attribute to it special anti-syphilitic power. More has been claimed for the bichromate, and it seems to have proved sometimes useful, especially in ulcerated throat (syphilitic) and in iritis; a pill containing $\frac{1}{10}$ to $\frac{1}{4}$ gr., with opium, is the best way of giving it, for its solution is apt to nauseate. In large doses it is an irritant poison, and its action as a remedy has not been well proved nor extensively tried. I have myself been greatly disappointed with its effects in some obstinate cases of syphilitic disease.

PREPARATIONS AND DOSE.—*Potassii bromidum* (*v.* vol. i., p. 119). *Potassii iodidum; Linimentum potassii iodidi cum sapone* (*v.* vol. i., p. 94). *Liquor potassæ:* dose, 10 to 60 min., freely diluted. *Potassa caustica. Potassæ carbonas:* dose, 10 to 20 gr., freely diluted. *Potassæ bicarbonas:* dose, 10 to 30 gr. as an antacid, etc.; in acute rheumatism, 30 to 60 gr. every four hours, freely diluted with water. *Liquor potassæ effervescens:* "potash water," dose, 4 to 8 oz. (contains $\frac{1}{4}$ gr. in the ounce). *Potassæ acetas:* dose, 10 to 60 gr. as a diuretic; 120 gr. and upward as a purgative. *Potassæ citras:* dose, 20 to 60 gr. *Potassæ tartras:* dose, 20 to 60 gr. as a diuretic and alterative; 120 to 200 gr. as a purgative. *Potassæ tartras acida:* dose, 20 to 60 gr. as a refrigerant or diuretic; 120 to 300 gr. as a hydragogue purgative (contained in confect. sulphuris). *Potassæ sulphas:* dose, 20 to 120 gr. as a purgative; smaller doses as an alterative. *Potassæ nitras:* dose, 5 to 20 gr. as a refrigerant and diuretic; 20 to 30 gr. as a vascular sedative. *Potassæ chloras:* dose, 5 to 20 gr. *Trochisci potassæ chloratis:* 5 gr. in each lozenge. *Potassæ permanganas:* dose, $\frac{1}{2}$ to 4 gr. *Liquor potassæ permanganatis* (contains 4 gr. to the ounce—for external use, 1 fl. dr. to 5 or 10 oz. of water). *Potassa sulphurata:* dose, 3 to 6 gr. in pill (often used in much smaller doses in pill or in water—$\frac{1}{10}$ gr. or even less for children). *Unguentum potassæ sulphuratæ* (should be recently prepared). *Sapo mollis.*

[PREPARATIONS, U. S. P.—*Potassa; Potassa cum calce* (equal parts of potash and lime); *Liquor potassæ; Potassii acetas; Liquor potassii arsenitis* (4 gr. in 1 oz.); *Potassii bicarbonas; Potassii bitartras; Potassii bromidum; Potassii carbonas; Potassii carbonas pura; Potassii chloras; Trochisci potassii chloratis* (5 gr. of the salt in each); *Potassii citras; Liquor potassii citratis; Mistura potassii citratis*—neutral mixture; *Potassii iodidum; Unguentum potassii iodidi* (60 gr. in 1 oz.); *Potassii nitras; Potassii permanganas; Liquor potassii permanganatis* (4 gr. in 1 oz.); *Potassii sulphas; Potassii sulphuretum; Potassii tartras; Potassii et sodii tartras*—Rochelle salt; *Pulveres effervescentes aperientes*—Seidlitz powders.]

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SODIUM—NATRIUM, Na,=23.

This metal does not occur native, but in various combinations is found extensively throughout all the kingdoms of nature; the chloride especially is abundant in the animal organism, also in sea-water, in many mineral springs and marine plants, as well as in mineral formations. The nitrate of soda occurs as an efflorescence on the soil in some countries.

CHARACTERS AND TESTS.—Sodium, the metallic base of soda and its compounds, is of waxy consistence, and silver-white color. It has a great affinity for oxygen, and when placed upon water floats like potassium, producing effervescence from escape of hydrogen, and combining with the oxygen of the water to form soda: the sp. gr. is 0.972. Sodium is the only metal of which the ordinary salts are all soluble in water, and therefore do not furnish precipitation tests: we have, however, an excellent reaction in the flame-test, *i.e.*, the communication of an intensely yellow color to a clear flame; so delicate is this test, and so universally diffused are the compounds of sodium, that it is difficult to obtain a flame perfectly free from all traces of them (Smith).

COMPOUNDS OF SODA.

SODA CAUSTICA—CAUSTIC SODA—HYDRATE OF SODA, NaHO,=40.

PREPARATION.—By evaporating liquor sodæ to dryness in a silver or clean iron vessel; the process is conducted as rapidly as possible to prevent absorption of carbonic acid, and plantinum, glass, or porcelain vessels are not admissible because the alkali would act upon them. A pure hydrate is now prepared by decomposing water with metallic sodium.

CHARACTERS.—Occurs in whitish cakes or pieces which are highly alkaline and corrosive: it is not so deliquescent as potash.

LIQUOR SODÆ—SOLUTION OF SODA.

PREPARATION.—By adding slaked lime to hot solution of carbonate of sodium, $Na_2CO_3 + CaH_2O_2 = CaCO_3 + 2NaHO$.

CHARACTERS.—A colorless liquid, of intensely caustic taste, containing nearly 19 gr. of caustic soda to the ounce.

SODÆ CARBONAS—CARBONATE OF SODA, $Na_2CO_3 10H_2O$,—286.

PREPARATION.—This is carried out on a large scale for commercial purposes, and is not described in the Pharmacopœia. The combustion

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of sea plants formerly furnished us with crude soda-ash, or "barilla," from which the carbonate was prepared, but it is now generally obtained from common salt (chloride of sodium) either by Leblanc's process of treatment with sulphuric acid, to form a sulphate known as "salt-cake," which is strongly heated in a furnace with chalk and charcoal, and afterward the carbonate is crystallized out; or by "the ammonia process," in which the bicarbonate of ammonia precipitates from the salt solution a bicarbonate of soda, and from this the carbonic acid is driven off by heat, to be utilized in other steps of the manufacture.

CHARACTERS.—Occurs in large rhombic crystals, colorless and transparent when fresh, but readily effloresceing on exposure to air; of nauseous alkaline taste, very soluble in water, not at all in alcohol: they contain 63 per cent. of water of crystallization, which they lose at a sufficient heat. Twenty grains of carbonate of soda neutralize 9.7 gr. of citric and 10.5 of tartaric acid.

Sodæ Carbonas exsiccata, or dried carbonate of soda, being the same salt deprived of water and powdered, is introduced as a separate preparation for convenience in dispensing: 1 gr. = about 2½ gr. of the crystallized salt.

SODÆ BICARBONAS—BICARBONATE OF SODA, $NaHCO_3$, = 84.

PREPARATION.—By passing a stream of carbonic acid gas into a mixture containing two parts of the crystallized and three parts of the dried carbonate, until the gas ceases to be absorbed. (If the ordinary carbonate only were used, the mass would become too moist, and the crystals too large): by a special arrangement of vessels, the delivery of the carbonic acid is made continuous, as in the case of bicarbonate of potash.

CHARACTERS.—Occurs in small snow-white grains or scales, or in opaque white powder, slightly alkaline, and somewhat caustic to the taste, permanent in the air, and soluble in water. Good commercial bicarbonate commonly contains 2 or 3 per cent. of carbonate. Twenty grains of the former salt neutralize 16.7 gr. of citric and 17.8 of tartaric acid.

Sodæ Arsenias (*v.* p. 26).

SODÆ SULPHAS—SULPHATE OF SODA—GLAUBER'S SALT, $Na_2SO_4 10H_2O$, = 322.

PREPARATION.—In the process for making hydrochloric acid, an acid sulphate of soda is formed by the action of sulphuric acid on common salt, and if this *acid* sulphate be neutralized with carbonate of soda, the *neutral* sulphate may be crystallized out.

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CHARACTERS.—Occurs in transparent colorless six-sided prisms, which are deeply channelled; they are efflorescent in the air, and have a saline bitter taste and neutral reaction.

SODÆ ACETAS—ACETATE OF SODA, $NaC_2H_3O_2 3H_2O$, =136.

PREPARATION, etc.—By neutralizing carbonate of soda with acetic acid: occurs in long striated prisms, which slowly effloresce, and have a sharp, bitter taste.

SODÆ HYPOSULPHIS—HYPOSULPHITE OF SODA (SODIC THIOSULPHATE), $Na_2H_2S_2O_4 4H_2O$ (*not officinal*).

PREPARATION, etc.—By warming a solution of the sulphite with powdered sulphur: occurs in large colorless oblique prisms, which are very soluble in water, not in alcohol.

SODÆ NITRAS—NITRATE OF SODA, $NaNO_3$, =85.

PREPARATION, etc.—This salt is found native in Peru and Chili, and is purified by crystallization from water. It occurs in the form of obtuse rhomboids, resembling cubes, deliquescent, and very soluble.

SODÆ PHOSPHAS—PHOSPHATE OF SODA, $Na_2HPO_4 12H_2O$, =358.

PREPARATION.—Obtained from bone-ash, which is mainly phosphate of lime, by rather a complex process, of which the essential steps are two, viz.: (1) The bone-ash is digested with sulphuric acid, when an acid phosphate is formed and remains in solution, and an insoluble sulphate precipitates. (2) The filtered solution containing the acid phosphate of lime is then treated with carbonate of soda to slight alkalinity, when phosphate of soda is formed, filtered, and re-crystallized.

CHARACTERS.—Occurs in large, transparent, rhombic prisms, which quickly effloresce in the air; they are faintly alkaline, very soluble in water, and have a mild saline taste.

SODÆ HYPOPHOSPHIS—HYPOPHOSPHITE OF SODA, $NaPH_2O_2$, =88.

PREPARATION.—By adding carbonate of soda to solution of hypophosphite of lime, so long as a precipitate (carbonate of lime) is formed; this is filtered off, and the solution evaporated cautiously.

CHARACTERS.—A white, crystalline, bitter salt, deliquescent, and very

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soluble in water and spirit. It readily decomposes, so that explosions occur with it on mixture, for instance, with chlorate of potash and friction; and when heated to redness it ignites, and gives off phosphuretted hydrogen.

SODÆ BIBORAS—BORAX, $Na_2B_4O_7 10H_2O$, =382.

PREPARATION.—Found native in a crude form in Thibet, India, California, etc.; also prepared by neutralizing boracic acid with carbonate of soda.

CHARACTERS.—Occurs in flattened semi-transparent prisms, of slightly alkaline reaction and saline taste, soluble in water, and efflorescing in the air. Its solubility is increased by glycerin and by cream of tartar, and from its solutions boracic acid is precipitated by any mineral acid: it gives a green color to flame. When heated it dissolves in its water of crystallization, and at red heat forms a transparent glass much used as a flux for mineral substances in blow-pipe operations.

LIQUOR SODÆ CHLORATÆ—SOLUTION OF CHLORINATED SODA.

PREPARATION.—By passing washed chlorine gas through a solution of carbonate of soda, till a sp. gr. of 1.06 is reached. The resulting solution contains hypochlorite of soda, with some chloride and bicarbonate of the same.

CHARACTERS.—A colorless alkaline liquid, with the odor of chlorine, and a pungent taste; sp. gr. 1.103; it bleaches vegetable colors, effervesces with acids, and readily evolves chlorine.

SODII CHLORIDUM—CHLORIDE OF SODIUM—COMMON SALT, NaCl, =58.5.

Is found native in "rock-salt" and saline waters.

CHARACTERS.—Occurs in transparent cubes or small white grains, soluble in water, and if pure, permanent in air: deliquescent, if containing chloride of calcium or magnesium.

SODA TARTARATA—TARTARATED SODA—TARTRATE OF SODA AND POTASH—ROCHELLE SALT, $NaKC_4H_4O_6 4H_2O$, =282.

PREPARATION.—By adding cream of tartar to a hot strong solution of carbonate of soda, so long as effervescence continues, then filtering and crystallizing.

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CHARACTERS.—Occurs in large, colorless, rhombic prisms, or halves of prisms, which have been compared to tombstones: they are neutral in reaction, soluble in water, and of saline rather bitter taste.

SODÆ CITRO-TARTRAS EFFERVESCENS—EFFERVESCENT CITRO-TARTRATE OF SODA.

PREPARATION, etc.—By mixing bicarbonate of soda with citric and tartaric acids, at considerable heat (200° F.); with constant stirring, this salt is obtained as a granular powder, which effervesces on contact with water.

ABSORPTION AND ELIMINATION.—The salts of soda, like those of potash, are highly diffusible and readily absorbed. Small doses become changed in the stomach into chloride, but large quantities undergo this change only in part, the rest being absorbed unchanged; from the rectum also, soda salts are absorbed without chemical decomposition. In the blood they circulate as albuminates, carbonates, phosphates, etc., and are eliminated mainly by the urine: the carbonates, nitrates, and other salts of *mineral* acids in their natural state, but citrates and other salts of *vegetable* acids pass out as carbonates.

The time that elapses between absorption and some elimination is not precisely known, but is short, for the nitrate and an excess of chloride have been found in saliva and urine within a few minutes after the taking of those salts; also, a very large quantity (60 grammes) of nitrate has been taken in divided doses during a day without injury, while half the amount in *one* dose has proved poisonous.

The chloride taken into, or formed in the stomach, is said to decompose into hydrochloric acid and soda, the former passing into the blood to combine again there with soda (bicarbonate), while the latter is eliminated, not only by the kidneys, but also by the salivary glands, the liver, the pancreas, etc. (Bidder and Schmidt). The chloride is never completely eliminated from the system even if it be excluded from the diet: on the other hand, if an excessive quantity be taken, most of it is rapidly got rid of: thus, Lehmann, analyzing his blood before and during the action of a salt-dose or salted diet, found the proportion of salt in the blood to be very similar, the excess being passed out by the kidneys almost as soon as taken (cf. p. 298).

Chloride of sodium in the air, or in finely-divided spray, is absorbed from the pulmonary mucous membrane even more quickly than from the stomach. It does not seem to be absorbed through the unbroken skin, or at least whatever passes, *e.g.*, during a salt-bath, into the epidermis or corium, passes out again in the same bath (Clemens). Soda salts, like alkalies generally, are eliminated to a slight extent by the mucous membranes, especially by those of the respiratory tract, the secretion of which

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they tend to increase and make thinner: they exercise a remarkable stimulant effect upon the vibratile movements of ciliated epithelium, which they revivify after apparent extinction (Virchow).

PHYSIOLOGICAL ACTION (EXTERNAL).—The *hydrate* of soda exerts a local caustic effect, consequent upon its great affinity for water and its power of dissolving nitrogenous tissues. The *carbonate*, applied in solution, dissolves sebaceous and fatty secretions, and if concentrated, acts as an irritant. Solutions of *chloride* redden and stimulate the skin, and if applied to a surface denuded of epithelium, excite much smarting and flow of serum; redness is then masked by whitish opacity of the albuminous secretion, and the same whitish appearance may be observed on the inner aspect of the buccal mucous membrane after eating much salted food (Gubler). Strong saline baths may cause cutaneous eruptions.

Salt has a local stimulant or irritant effect on nerve-tissue, and for some physiological experiments, C. Bernard considered it more effective than galvanism. If the exposed sciatic nerve of a frog be dipped in salt and water, immediate spasmodic contraction of muscles occurs in the limb: if the tympanic nerve be so treated, saliva is secreted (*Medical Times*, ii., 1861).

PHYSIOLOGICAL ACTION (INTERNAL).—*Oxidation and Nutrition.*—Under potassium has been summarized evidence as to the action of alkalies on oxidation, and with regard to the carbonates of soda, we may equally conclude that while large and continued doses induce anæmia and asthenia, small quantities, given for a moderate time, help to saponify fatty food, to aid its oxidation, and that of carbonaceous material generally, to improve digestion, and to raise temperature. This is especially the case with the chloride of sodium, and indeed Rabuteau teaches that it is by conversion into this salt that the other sodium compounds produce the good effects mentioned. Confirming conclusions already published by Voit (*British and Foreign Review*, ii., 1862), he showed that the chloride increased "vital combustion," for while taking an extra daily dose of 10 grammes of salt, his excretion of urea was 20 per cent. more, and his temperature was half a degree higher than when under a dietary from which salt was excluded. Similarly Kaupp found that with taking 1 gramme of salt, the amount of urea excreted was increased 4 ctgr., the other soluble constituents of the urine being diminished. According to Zabelin, salt favors absorption of phosphates specially, and rather hinders their excretion, which effect would, to some extent, favor nutrition.

Falck found also increased excretion of urea after giving salt to fasting animals (1872), while Münch reported, from large doses, continued for a few days, at first diminished excretion and gain in weight: afterward a contrary effect (*Archiv Verein Gemeinshft.*, Bd. vi.).

The carbonate, according to the majority of observers, diminishes the

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excretion of uric acid, and as this acid results from insufficient oxidation, its diminished excretion implies improvement in oxidation. The reported increase of excretion of carbonic acid requires proof, but is rendered probable by the increase which follows injection of lactate of soda into the veins (Husemann). Animals improve under a ration of salt—their coat becomes smoother, their vigor greater, their flesh more healthy, and if, at the same time, their weight is not increased (Boussingault and Dailly: *Comptes Rendus*, 1847), it is because the vital processes and combustions all go on with greater energy. We have negative evidence to the same effect in the sufferings consequent on deprivation of salt, as in the American War of Independence, and more lately during the siege of Metz, and Barbier records that certain Russian serfs, deprived for a time of salt (from motives of economy), suffered so much (becoming albuminuric and dropsical), that their lords were forced to supply them with it again (*Gazette Médicale*, 1838). On the other hand, it is curious that the Tlascalans are said to have lived for half a century without salt (Prescott), and certain Aryan tribes never use it (Fick)—it is possible that the atmosphere, as near the coast, may supply to them what is really necessary.

We must repeat that the above-mentioned good effects of ordinary salt, and of alkaline compounds, are obtained only within certain limits of dose—an excess of the former causes not only thirst and disordered digestion, but impaired blood-conditions, and under daily 5-gramme doses of bicarbonate the urea is diminished, and anæmia and prostration induced (Rabuteau): the nitrate and sulphate also diminish urea (Jovitzu and others), lower temperature, and slow the circulation:—it is probably from alteration of the blood that these effects arise. According to Guttman, if the legs of frogs are immersed in strong solutions of salt, unrest and local swelling occur, then muscular contraction, and ultimately cataract is developed (*Medical Times*, i., 1860).

Digestive System.—What has been stated under potassium as to the influence of alkalies upon digestion and secretion applies equally to the alkaline salts of soda, but the chloride of sodium has a special value, perhaps from its furnishing in part the gastric acid; it aids the solution of albuminous substances, and increases the amount of saliva and gastric juice. Bardeleben proved this by observations on dogs with gastric fistula, though, indeed, many other salts, and even mechanical irritants, will provoke a temporary increase in the gastric secretion. Rabuteau found that salted diet increased also the degree of its acidity, whether from irritation, or from the special properties of the chloride itself; certainly digestion suffers by its absence (Klein and Verson). The good effects are shown by small doses of 15 to 60 gr. Large quantities tend rather to coagulate albumen, while very large and concentrated doses cause vomiting, watery purging, and even gastritis:—in China, they are said to be used

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for suicidal purposes. Injection of much salt into the crural vein of dogs causes ptyalism, intestinal gurgling, and temporary lessening of the spleen (Podocæpow).

Different osmotic currents are determined by the different modes of administration; when either the chloride or sulphate of soda is injected into the blood, or taken in small quantities that can be quickly absorbed, constipation follows, while large amounts, given at one time, induce hyper-secretion and consequent purgation.

The action on bile-secretion is not certainly known: Nasse, experimenting with animals, found it lessened, but observations made after the use of alkaline waters show an increase (Grossmann), and this would be in accord with analogy. Rutherford has shown that sulphate of soda has marked cholagogue properties. According to Pavy, the carbonate not only increases the bile, but also the percentage of fat in the liver, and when introduced into the portal system causes the disappearance of hepatine, without formation of sugar (*Guy's Reports*, 1861, "Proc. Roy. Soc.," vol. x.–xi., *Medical Times*, i., 1865): also the saccharine urine which commonly follows certain traumatic lesions of the sympathetic, does not occur if much soda be previously introduced into the blood; these are curious facts, of which we do not at present see the full bearing (cf. p. 301).

Circulatory System.—It is an important difference between potash and soda, that the former is an active cardiac depressant and poison, while the latter has no definite effect on the heart-muscle or the circulation. Frogs, it is true, die, but only slowly, after the injection of very large quantities (Podocæpow, Guttmann), while upward of 100 gr. of soda carbonate have been introduced into the vein of a dog with but slight and temporary malaise and muscular weakness (Grandeau: *Robin's Journal*, 1864). Upon man, large doses seem to have but little effect in directly depressing the circulation.

The chloride of sodium, in small or moderate doses, *increases* the number of corpuscles; thus Plouviez had analyses made of his own blood before and after a course of salt, lasting two months, during which he took daily 150 gr. of salt besides his ordinary allowance, and at the end of the time the red globules were augmented 10 per cent., the fibrine was increased, the albumen diminished (*Comptes Rendus*, 1847, t. xxv.).

Rabuteau states that blood-corpuscles placed under the microscope disintegrate much less rapidly when salt is added than with simple water, and from this and general physiological results concludes that any influence of salt in apparently increasing the number of globules is exerted by *conserving* them, rather than by supplying food for fresh ones, as iron does.

According to Bergeret, *omission* of salt from a dietary leads to pallor, languor, œdema, and a chlorotic condition, the corpuscles are dissolved,

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and fibrine deposited (*Abstract*, Ranking, i., 1871; cf. p. 296), but on the other hand, the *continued use* of soda, as of any other alkali, lessens the number of red corpuscles and deteriorates the blood (Loffler, *v.* p. 270).

Whether the excessive use of highly salted food is the main cause of scorbutic conditions, such as occur in sailors and at whale-fisheries, may be considered doubtful; they may arise from the hardships of such life, from deficiency of potash, of vegetables, etc., but it would almost seem as if either great (relative) *excess* or *deficiency* of the element led to equally injurious consequences. Prussac found that when frogs were placed in concentrated salt solutions or had them injected into the lymph sacs, copious "wandering" of red corpuscles took place from uninjured vessels, and also capillary hemorrhage (cf. p. 293).

External to the body, salt reddens and liquefies blood-clot. The change in color is attributed by Gubler to liberation of carbonic acid and absorption of oxygen by the hæmoglobin. It is permanent, but I do not think it more than a physical change due to altered osmosis; it may be produced by many other saline compounds.

Soda is more abundant in the serum, while potash occurs most in the red globules, and excessive doses of the former alkali may alter this normal relationship, and thus interfere with respiratory combustion and with nutrition.

The proportion of sodium chloride in normal blood has been variously estimated at from 3 to 5 per 1,000. It is diminished in various morbid states, such as cholera, diabetes (Nasse), jaundice, chlorosis; in pneumonia, on the contrary, its elimination is checked, and hence an excess remains in the blood (Beale: *Lancet*, i., 1852; Bergeron: "Thèse de Paris," 1866, and others).

Nervous System.—There is some (not cogent) clinical evidence that excess of soda in the blood leads to convulsive action of the nervous system (Laycock: *Medical Times*, i., 1863; Hunt: *Medical Times*, 1856); most observers think an excess of little import.

Urinary System.—With regard to the influence of soda salts on diuresis, opinions are divided, partly, perhaps, because of the different doses employed. Usually some increase in the quantity of urine passed is observed in patients taking carbonates, especially in those with acid dyspepsia, but it is not always the same with healthy persons. Münch found, in five subjects, when perspiration or diarrhœa did not occur, *increased excretion of water* as the principal effect of 3 to 6 or 9-gramme doses of carbonate, but Rabuteau and Constant could not verify any increase with 5-gramme doses, given daily. A continued weak alkalescence of the urine may be secured from about 3-gramme doses of bicarbonate of soda, taken thrice daily at meal-times, while one daily dose of 5 gr. will give alkalinity only for two or three hours—even 1 gramme will do this if taken fasting. Much dilution or warmth of the liquid in

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which the drug is taken promotes the alkalescence of urine, and it lasts longer in weak or elderly persons.

The chloride will produce the same effect, though not so quickly as the carbonate, and under its use earthy phosphates replace free acids (Münch).

Glandular System.—Milk is secreted in increased quantity under the influence of salt. This fact, indicated by Saive, but denied by Boussingault, has been confirmed recently (Rabuteau). In Brazil and some other countries there is a popular custom of watering the food of milch cows with salt water to increase their milk.

SYNERGISTS.—The chemical action of the alkaline salts of soda is shared by other alkalies, the physiological action of the chloride of sodium by other chlorides, both as stimulant of hæmatosis and as irritant in large doses; as *digestive* stimulant, other condiments assist its power.

ANTAGONISTS—INCOMPATIBLES.—Acids antagonize the chemical effects of alkaline salts of soda, though the vegetable acids are often added to them to secure liberation of carbonic acid gas and formation of neutral salts. Mucilaginous substances lessen the local irritant effects of excessive doses of chloride, nitrate, etc., and the chloride itself is a suitable antidote for nitrate of silver. Prussic acid and cyanides, perhaps also arsenic and antimony, antagonize the hæmatinic effects of chloride of sodium.

THERAPEUTICAL ACTION (EXTERNAL).—*Strumous Ulceration, etc.*—For destroying unhealthy growths, the edges of strumous ulceration, etc., caustic soda has been sometimes used. It is less deliquescent than potash, but yet is very diffusible, and readily extends its action: it therefore requires the precaution of protecting adjacent parts, and of neutralizing with weak vinegar or oil after application.

Glandular Scrofulosis.—A strong solution of salt locally applied is a good resolvent of enlarged and hard glands: sea-bathing is useful for the same purpose.

Frictions with a pomade containing salt cause a pustular eruption, and have been used over the chest in phthisis (*Medical Times*, ii., 1859).

Hoarseness—Catarrh.—A piece of borax allowed to dissolve slowly in the mouth sometimes cures these conditions. A spray containing salt (gr. iv.–v. ad. ℥ j.) is also useful.

A simple mode of stimulating the external surface in some chronic catarrhs and relaxed throat-conditions, is sponging or bathing of the neck and chest in salt water night and morning, following this with friction.

Unhealthy Wounds.—Solution of chlorinated soda mixed with water in various strengths makes an excellent detergent and disinfectant gargle, lotion, or injection, but is rather a preparation of chlorine than of soda.

Corneal Opacity.—Mr. Henry Power has recorded good results from

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the local application of powdered sulphate of soda to the cornea, though it is liable to cause severe irritation for a time (*Practitioner*, September, 1868).

Lupus.—The acetate of soda, though not often used, has remarkable power in lessening the granulations and crusting of strumous and lupoid ulceration: a lotion containing from 10 to 20 gr. in the ounce of water may be applied on compress, or injected into sinuses. In lupus the solid crystals may be lightly applied for a caustic effect (Anderson: *Lancet*, ii., 1869).

Pruritus—Eczema, etc.—In several forms of skin disease, attended with itching, lotions containing a small proportion of carbonate or borate of soda, 1 to 2 dr. in ½ pint, are often serviceable. In urticaria, lichen, and the early inflammatory stages of eczema, when alkaline oozing occurs, the same lotion will give relief, but in the last case it should be made weaker still—20 to 30 gr. in the ½ pint; or, again, 20 gr. of the carbonate of soda may be usefully combined with an ounce of zinc ointment. In several forms of papular and scaly eruptions, such as *lichen* and *psoriasis*, baths containing about 4 to 6 oz. of carbonate of soda are very useful, being sedative as well as detergent. For common *chilblains* a strong solution of salt in water is a good domestic remedy; borax with glycerin is also good.

A weak lotion of borax is also often useful in cases of ordinary *sore nipple;* Sir Astley Cooper commonly prescribed it with spirit of wine. For slight cases of fissured *sore tongue* or buccal irritation, the glycerine of borax is pleasant and efficient.

Tinea Versicolor and even mild cases of tinea tonsurans (ringworm) may be cured by the same remedy. For the irritation and scaling connected with so-called *pityriasis capitis* a lotion containing borax, camphor, and rosemary is a good application.

Aphthæ, etc.—Aphthous conditions affecting the mouth and fauces are often treated with borax mixed with honey or dissolved in glycerin; a solution of chloride will also succeed sometimes. Aphthous conditions affecting the vulva, and the very irritating "pruritus pudendi" in either sex, may be much relieved by warm lotions or by paints containing borax. Laycock has spoken well of the use of borax in *diphtheria* (*Medical Times*, i., 1858, p. 548), but we have more dependable remedies.

Acne Simplex.—A liberal use of soap with hot water is often necessary in this disorder, and a borax lotion is of service.

Burns.—In burns and scalds, especially of the first degree, a saturated solution of the bicarbonate, applied constantly on moistened cloth, quickly relieves the burning pain.

Dental Caries.—Toothache, connected with open carious teeth, may often be relieved by the local use of carbonate of soda (½ dr. in the ounce of warm water); it probably acts by neutralizing acid or irritant secretions (Duckworth: *Practitioner*, 1875).

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Rheumatism—Gout.—Soda baths are also useful in relieving pains of rheumatic character in the joints and muscles. Basham recommended basic phosphate of soda in powder as a good application for enlarged and painful gouty joints (*Medical Times*, ii., 1848), and it has some advantage over liquid applications; it may be applied on moistened spongio-piline. Hot salt in flannel is often a convenient mode of applying warmth to rheumatic or painful parts: in similar cases Dr. H. Bennett used "soda poultices" (*Times*, ii., 1853, p. 502).[1]

Leucorrhœa—Cystitis.—Injections containing carbonate of soda (1 to 2 dr. in the pint) form a simple and often efficacious remedy in cases of vaginal leucorrhœa with white, alkaline discharge, and in chronic cystitis an injection of borax, glycerin, and warm water is very soothing. The silicate of soda has been lately recommended for the same purpose; it coagulates albuminous material, and is antiseptic (Ranking, i., 1873).

Ascarides, etc.—A strong injection of salt into the rectum is an efficient cure for these parasites, and is best given with quassia or other bitter. Salt is also taken internally to prevent recurrence of thread or round worms, and so strong at one time was the belief in its efficacy, that an ancient law in Holland deprived certain criminals of salt in their diet, in order to allow intestinal worms to develop and devour the victims!

Leeches are very sensitive to the action of salt; it will make them disgorge blood they have swallowed, and a saline injection will dislodge them from the rectum or vagina. It is advisable to administer the same remedy freely should they by accident have passed from the nose or mouth to the stomach.

Fractures, etc.—The silicate of soda (water-glass) is used like the analogous salt of potash. Bandages soaked in the fluid harden into a light firm support in twenty-four to forty-eight hours.

THERAPEUTICAL ACTION (INTERNAL).—Comparing soda with potash, we find the former more indicated in disorders of the stomach, the primæ viæ, and the liver, while the latter, acting better as a diuretic and a solvent of uric acid, is more appropriate in renal congestions and lithiuria.

Dyspepsia.—Soda salts are very useful in several forms of indigestion, but the dose and mode of administration vary somewhat according to the conditions present. In cases of *atonic* dyspepsia connected with deficient secretion of gastric juice, the bicarbonate in small doses of 5 to 10 gr. should be given, and shortly *before* a meal, on the principle already alluded to, viz., that an alkali causes increase of an acid secretion, for though on first contact it neutralizes the acid it meets with, additional acid is very quickly poured out so as to leave an excess. The alkali may, in some cases, be very suitably combined with an aromatic, as in

[1] Soda salts are, by some practitioners, given internally for rheumatism, like potash (*v.* p. 279): the use of the salicylate will be discussed under salicylic acid.

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"Gregory's powder," with ginger only, or with a bitter-like tincture of orange or infusion of gentian. On the other hand, in cases of *acid* dyspepsia, with thickly coated or red shining tongue, sour eructations, heartburn, and flatulence, larger doses of the bicarbonate (15 to 20 gr.) should be given an hour or more *after* a meal, according to the time at which the symptoms come on; in this case, also, the remedy may be well combined with an aromatic or stimulant, as ammonia or peppermint. Soda is especially useful for the dyspepsia of those who live in towns, eating and drinking freely, and taking little exercise. If the urine be scanty and irritating, nitre may be given at the same time, and according to Dr. Budd, an occasional blue pill. A dry skin and very furred tongue are other indications for soda, while for those who live in the country, take more vegetable food, and perspire freely, acids usually agree better (*Medical Times*, i., 1854). If larger doses of soda be continued too long, or taken at the wrong time, "it becomes a contest between the stomach and the doctor."

The familiar use of salt is of no small importance in stimulating appetite and digestion, and advantage is sometimes gained by varying the kind used: thus, Maldon salt is in crisp flakes, Lymington salt in deliquescent cubes, etc. (*Medical Times*, i., 1864). The principal ingredient in Vichy water is the bicarbonate of soda, but it contains minor or minute quantities of sulphate, phosphate, arseniate, borate, and chlorine: this saline water may be very useful in simple *slow* digestion, with constipation and loss of appetite, and when gastralgia is not a prominent symptom (H. Weber: *Medical Times*, ii., 1861). Dr. Symonds states that "duodenal dyspepsia," with its attendant "bilious headache," may often be obviated for a long period by the daily taking of a tumblerful of "salt and water" before breakfast (*Medical Times*, i., 1858). An effervescent soda carbonate, or sulphate, is often efficacious in such headaches.

Lientery.—In the lientery of young children, Rabuteau has found salt curative after other remedies had failed (op. cit. p. 104).

In *Vomiting* or *Diarrhœa* connected with acidity, or with incomplete digestion of fatty food, the bicarbonate of soda, with an aromatic, such as cinnamon, is very good. In children with coated, irritable, or aphthous tongue, it may be combined with a little gray powder, and for adults, especially if colic is present, it may be given in effervescence with opium. In cases of dyspepsia, etc., in weakly subjects, the use of alkalies must not be too long continued.

Hepatic Disorders.—For congestion of the liver, with deficient secretion of bile, soda is of proved value in several combinations, and it relieves such symptoms as have been already described under dyspepsia.

Phosphate of soda especially is said to promote the flow of bile, and acting in full doses as a gentle laxative, it is useful in "bilious or sick headache," and in catarrhal jaundice. It has some value, also, in pre-

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venting biliary calculus, which condition arises generally from continued catarrh of the bile-duct and inspissation of mucus and bile. (Vichy water presents a good natural combination for such cases and for chronic hepatic congestion.) The salt cannot be expected to control fully developed attacks of biliary colic, but if a dose of 20 or 30 gr. be taken regularly before meals for some months, it seems to have the power of lessening the calculi, or preventing fresh formations (Bartholow, p. 80); from larger doses (1 to 2 dr.) of the carbonate in copious draughts of hot water, Dr. Prout has often seen immediate relief even during the attack of colic.

In *fatty degeneration of the liver* we have the authority of Dr. Murchison for saying that large quantities of common salt, eaten with the food, have proved useful, and there is at least encouragement to try saline waters in this condition ("Clinical Lectures," p. 51). In the case of ill-conditioned children passing pale and pasty stools, 5 or 10 gr. of the phosphate taken with meals, will often serve to regulate digestion and improve nutrition (Stephenson).

Renal Diseases.—In cases of calculous (uric acid) diathesis, if it be desired to keep the system under the continued influence of alkalies, the salts of soda have sometimes been preferred in weakly dyspeptic subjects, being less depressing than those of potash commonly used. The waters of Vichy have a special reputation in such conditions, and under their influence a urate of soda replaces uric acid in the urine, and is more readily eliminated. The phosphate was especially commended by Liebig and by Golding Bird as a solvent of lithic deposit.

In *Albuminuria* it has been recommended to supply alkalies freely to the blood in order to lessen the liability to inflammation, and to dissolve fibrinous deposits. It has been taught also that they further the oxidation which is deficient in this dyscrasia, but they can only do so in a slight degree, if at all. Soda, like other alkalies, may be occasionally useful in relieving the dyspeptic symptoms, but is no cure for albuminuria, and its prolonged use is contra-indicated by the tendency to anæmia.

Diabetes.—Speaking not of the temporary and accidental passage of sugar into the urine, but of the more permanent malady, diabetes, we find that small doses of bicarbonate or of chloride of sodium often lessen the amount of sugar passed (Clarke of New York, and others).

The citrate, ½ to 1 dr., used, instead of common salt, with the food, is said "to cure saccharine urine" (Ranking, ii., 1866), and alkaline waters have been largely used in the treatment of this condition. At Vichy and similar springs it is found that stout diabetics derive advantage from the waters, when thin and pale patients do not. Transitory cases, such as have arisen from temporary nerve-causes, from carbuncle, etc., often do well at Vichy, and even old-standing cases have been relieved, but

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those with marked lesion of the pulmonary or digestive organs are not suitable for this treatment.

Ebstein reports favorably of Carlsbad and other alkaline waters, especially for mild cases (*Medical Times*, i., 1875). According to the theory of Mialhe, they should help to oxidize—burn up—sugar in the system, but their use cannot be based on this hypothesis. Poggiale fed dogs with non-nitrogenous food—starch and sugar—to which he added enough soda to render alkaline the urine, but their blood contained as much glucose as that of dogs fed without any soda; also he injected glucose into the blood of rabbits, and again injected it mixed with soda, in each case finding sugar in the urine, while under tartaric acid the sugar disappeared (*Bulletin de l'Académie*, 1866, cf. p. 294). Bouchardat, on the other hand, points out that alkalies may act dangerously in increasing both fluidity of the blood, and tendency to apoplexy or pulmonary congestion, and Rabuteau cites several cases that died soon after commencing Vichy treatment. He suggests that whatever benefit is derived from soda salts is really due to the chloride, and according to Nasse and others this salt is deficient in the blood of diabetic patients. Martin Solon (*Bulletin Générale*, 1842–43), Constant (Thèse, 1844), and Bouchardat have reported some clinical illustrations of the good effects of salt given as medicine to such subjects.

Struma—Phthisis.—Some writers have much insisted on the therapeutical virtues of salt in these diseases. Durand Fardel reported instances of benefit, and Amedée Latour reduced its administration to a system; he gave it to well-fed goats, and then used the goats' saline milk largely in the diet of his patients; he employed also all hygienic means, and obtained good results (*Union Médicale*, 1851–56, Brochure, 1857). Piétra Santa is another advocate for the systematic use of salt in phthisis, recommending a "syrupus natrii chlorati." Dr. Cotton, however, could not trace any definite effects from salt in his treatment at Brompton Hospital. The saline baths of Soden, in Nassau, have a reputation in similar cases, and in *obstinate chronic catarrh* the waters of Ems are often prescribed with advantage.

Intermittent Fever.—There is evidence of a favorable influence being exerted by salt in ague and some of its complications. Piory used it, and Gintrac gave 30 grammes daily with success except in quartans; he did not verify reduction of the spleen (Bordeaux, 1850), but Herschel and Rondelet have done so after a more prolonged use of the remedy. At Bruges, forty-eight cases were reported, and all of them, except the quartans, were convalescent in three to four days, after taking from 30 to 45 grammes of salt daily, freely diluted; it cleansed the furred tongue and improved appetite. Out of fifty-two cases reported from Africa the greater number were cured with 15-gramme doses of salt (*Union Médicale*, 1851), and Villemin states that, according to his experience at Damas-

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cus, common salt stopped attacks of ague six times out of every seven, ½-oz. doses being given two, three, or four times (*Gazette Hebdom. de Méd.*, March, 1854). Mareschkin, a Russian physician, has recently given further evidence to the same effect (*Bulletin Générale de Thérapeutique*, vol. li., p. 183).

Cholera.—The carbonate of soda has been used both by the stomach and by injection in cases of cholera, but the chloride has been more depended upon.

A reasonable argument may be given for its employment, for a main fact in the disease is profuse discharge by osmosis from the vessels of the intestinal tract into the alimentary canal; this by itself can determine the cyanosis, shrunk features, blood stasis, etc. It depends upon a change in the albuminous constituents of the blood, and is increased by desquamation of intestinal epithelium, while by saline injections the physical conditions may be so far altered as to lessen such osmosis. Both rectal and venous injections have been used, and benefit also has been traced to salt given by the mouth in cases when the power of absorption has been retained.

During an epidemic at St. Petersburg (1830) salt water and salt milk relieved as much as any other remedies. In 1835, at Paris, Bracton reported fifty cases of Asiatic cholera treated with common salt, and only one was fatal; two tablespoonfuls were given dissolved in 6 oz. of water. Chomel, Aran, Richard, and others reported good results from the same treatment in the epidemic of 1865. On the other hand, Husemann concludes that the use of salt has no really good effect, and states that its intravenous injection has sometimes caused asphyxia. The question cannot yet be considered decided.

For *Dysentery*, the sulphate of soda has been much commended by American writers: 1 dr. is given with ¼ gr. of morphia every two hours, until natural, though loose, evacuations occur; this treatment is said to control the malady in two or three days (*New York Medical Record*, February, 1872).

Constipation.—On the other hand, the same remedy (soda sulphate), when given in larger doses of ½ oz., is a useful saline purge in inflammatory conditions, and is an ingredient in several natural aperient waters: if given with sulphate of magnesia or acid tartrate of potash, smaller doses (1 to 2 dr.) may be used. The phosphate of soda acts in the same manner on the intestinal tract, and has a more decided diuretic action; it renders the urine alkaline. Tartarated soda is an ingredient of Seidlitz powders.

Uterine Inertia.—Borax has some stimulating effect upon the uterus, as shown by its increasing contraction during labor; it has been used in lingering cases, though generally combined with ergot and cinnamon; it is nauseous in taste. Borax has been given also in *amenorrhœa*, with or

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without aloes, and in *dysmenorrhœa* with belladonna, but is not in general use. Since this is the only soda salt that acts upon the uterine system, it probably does so through the boracic acid.

Epistaxis—Embolism.—Common salt is an ordinary domestic remedy for bleeding at the nose, and even for hæmoptysis, and cases of the former are sometimes favorably influenced by it when given in drachm doses. Some attribute any benefit from salt in hemorrhage to the nausea excited, but it is more likely from a reflex contraction of vessels consequent on irritation of gastric nerves (Husemann). It has been stated that in *embolism*, the collateral circulation becomes better established under the influence of an alkali (soda carbonate), though the thrombus itself is not affected (*British and Foreign Review*, ii., 1861).

Preparations and Dose.—*Liquor sodæ:* dose, 10 to 60 min. freely diluted. *Soda caustica. Sodæ carbonas:* dose, 10 to 30 gr. or more. *Sodæ carbonas exsiccata:* dose, 5 to 15 gr. *Sodæ bicarbonas:* dose, 10 to 60 gr. *Liquor sodæ effervescens—soda water:* dose, 2 to 10 oz. or more—each pint contains 30 gr. of bicarbonate of soda. *Trochisci sodæ bicarbonatis:* dose, 1 to 6—each lozenge contains 5 gr. *Sodæ arsenias* (*v.* Arsenic). *Sodæ sulphas:* dose, ¼ to 1 oz. *Sodæ acetas:* dose, 20 to 60 gr. *Sodæ sulphis* (not officinal): dose, 20 to 60 gr. (*v.* Sulphurous Acid). *Sodæ hyposulphis* (not officinal): dose, 20 to 60 gr. *Sodæ nitras* (for making the arseniate). *Sodæ phosphas:* dose, as a *diuretic*, 30 to 120 gr.; *purgative*, ½ to 1 oz.—given in mutton broth it is almost tasteless. *Sodæ hypophosphis:* dose, 5 to 10 gr. (*v.* Phosphorus). *Borax:* dose, 10 to 60 gr. *Mel boracis:* contains 54 gr. of borax to 1 oz. of honey. *Glycerinum boracis:* contains 1 part to 4. *Liquor sodæ chloratæ:* dose, 10 to 20 min. internally, diluted with 1 or 2 oz. of water; as gargle, ½ to 1 oz. to ½ pint water. *Cataplasma sodæ chloratæ* (solution of chlorinated soda 2 oz., linseed meal 4 oz., water 8 oz.). *Sodii chloridum:* dose, ½ oz. or more as an emetic. *Soda tartarata* (*Rochelle salt*): dose, as a *diuretic*, 30 to 60 gr.; *purgative*, 2 to 4 dr. *Sodæ citro-tartras effervescens:* dose, 60 gr. to 2 dr. *Sodæ valerianas* (*v.* Valerian).

[Preparations, U. S. P.—*Soda; Liquor sodæ; Liquor sodæ chlorinatæ; Sodii acetas; Sodii arsenias; Liquor sodii arseniatis* (4 gr. in 1 oz.); *Sodii bicarbonas; Pulveres effervescentes; Trochisci sodii bicarbonatis* (3 gr. of the salt in each); *Sodii boras; Glyceritum sodii boratis:* borate of sodium 2 troyounces, glycerin ½ pint; *Mel sodii boratis:* borate of sodium 60 gr., clarified honey 1 troyounce; *Sodii carbonas; Sodii carbonas exsiccata; Sodii chloridum; Sodii hypophosphis; Sodii hyposulphis; Sodii phosphas; Sodii sulphas.*]

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STANNUM—TIN, Sn,=118 (not officinal).

This metal is known to occur only in the mineral kingdom, and in minute quantity in the water of Sadschütz.

CHARACTERS AND TESTS.—Silver-white in color, with a tinge of yellow, and high metallic lustre, unaffected by moisture or exposure, inelastic, but flexible; when rubbed it imparts to the fingers a peculiar odor. It is a good conductor of heat and electricity, has a sp. gr. of 7.292, melts at 442° F., and at a higher temperature burns with a brilliant white light; at ordinary temperatures it is not brittle, but when heated to near the fusing point may be easily powdered. Nitric acid does not act upon it, except in presence of water; hydrochloric acid dissolves it with evolution of hydrogen.

Solution of *chloride of tin*, $SnCl_2$ (Appendix, B. P.), absorbs oxygen readily, and hence is a powerful deoxidizing agent. It reduces to the metallic state the salts of mercury, silver, gold, etc., and is made use of for this purpose; also as a test for ammoniated mercury.

PHYSIOLOGICAL ACTION (INTERNAL).—The metal itself is inert, but if taken into the stomach may be so far acted on by acids or saline substances as to be rendered soluble in the form of chloride, and may then produce some irritant effects. The fact of such a change sometimes occurring, and sometimes not, may explain the disagreement between the results of Orfila, who considered oxide of tin to be a poison, and Schubarth, who considered it inert.

It has been said that fatty, or acid, or simply albuminous articles of food, after having been kept in tinned vessels (free from lead) have sometimes occasioned colic and vomiting, but this must be exceptional. We may note that arsenic is a usual constituent of tin-ores, and in small quantity it is generally present in all tin that has not been carefully purified, and irritant effects may have occurred from it (Gubler).

The *chloride*, or "*butter of tin*," is stated to exert a tonic, antispasmodic effect, when given in small quantities, but in large doses it causes muscular twitching, convulsion, and paralysis; also some gastro-intestinal irritation, with dryness of mouth and throat.

THERAPEUTICAL ACTION.—*Intestinal Worms.*—The powder of tin (tin filings) has been used as a vermifuge in cases of lumbricus and tænia.

Trousseau remarks that of all metals after mercury, tin has been in the highest repute as anthelmintic, and many secret vermifuges contain either the finely powdered metal or its sulphide: from 30 gr. to ½ oz. have been given in electuary. Alston gave 1 oz. at a time, but severely irritant effects sometimes followed. Professor Stillé quotes several authorities in favor of the remedy, and Dr. Graves speaks well of it ("Lectures," ii., p. 248), but it is not now much used, because more dependable

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medicines have been found. It is supposed to act either mechanically or by disengagement of hydrogen or other chemical effects. Salts of di-stann-ethyl have a strong purgative action (Jolyet and Cahours).

In *Epilepsy*, *Chorea*, and allied forms of nerve-disorder, the chloride of tin has been given with benefit, according to the observations of Dr. Schlessinger (*Medico-Chirurgical Review*, October, 1838, and April, 1846).

In *Chronic Skin Diseases*, the same physician recommends it both internally and in lotion, but its real value is not ascertained.

PREPARATIONS AND DOSE.—*Pulvis stanni* (not officinal): dose, 20 to 40 gr. as a vermifuge—it may be given in honey or treacle three or four times daily for several days, and should then be followed by a cathartic. *Stanni chloridum:* dose, $\frac{1}{16}$ to $\frac{1}{2}$ gr. two or three times daily in pill or in chloric ether—*a lotion* may be made with 1 gr. to the ounce.

ZINCUM—ZINC, Zn,=65.

This mineral is obtained, for commercial purposes, mainly from two ores—the carbonate (calamine) and the sulphide (blende)—by distillation with carbon. It has been found also in plants which grow on the calamine hills of Rhenish Prussia. It is liable to contain arsenic, iron, copper, and sulphur. Alloyed with copper, zinc forms brass; with nickel, "German silver." It is extensively used in galvanic combinations, and forms the positive plate of many voltaic batteries; as a coating on iron (galvanized iron) it protects from oxidation. Granulated zinc is prepared by pouring the molten metal into cold water.

CHARACTERS AND TESTS.—Zinc is a brittle bluish-white metal, which at a red heat burns with a brilliant flame, and emits white fumes of oxide; sp. gr. 7. It is the only metal which yields a white sulphide with sulphide of ammonium, and hence this reaction is the characteristic test for it. Fixed and volatile alkalies also give with zinc white precipitates, soluble in excess of the reagents.

COMPOUNDS OF ZINC.

ZINCI OXIDUM—OXIDE OF ZINC, ZnO,=81.

PREPARATION.—By exposure of the carbonate to a dull red heat until all the carbonic acid is driven off. "Hubbuck's" oxide of zinc is obtained by combustion of the metal in air.

CHARACTERS AND TESTS.—A white heavy powder, without taste or odor, insoluble in water, soluble in acids; moderate heat renders it yel-

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low. Commercial specimens are often impure from presence of carbonates, sulphates, chlorides, iron, etc.

ZINCI CHLORIDUM—CHLORIDE OF ZINC, $ZnCl_2$, =136.

PREPARATION.—By dissolving zinc in hydrochloric acid, and evaporating the solution; chlorine water is then added (to combine as chloride with the iron usually present), and afterward zinc carbonate, which forms more zinc chloride and precipitates ferric oxide.

CHARACTERS.—Chloride of zinc is soft, white or semi-transparent, crystalline or waxy, and is met with either in opaque tablets or in pencils like nitrate of silver. It is very soluble and deliquescent, but if mixed with an equal part of oxide (oxychloride), may be kept dry for a long time.

ZINCI SULPHAS—SULPHATE OF ZINC—WHITE VITRIOL, $ZnSO_4 7H_2O$, =287.

PREPARATION.—By dissolving zinc in dilute sulphuric acid: chlorine water and carbonic of zinc are added, as in the last preparation, and for the same purpose, viz., to remove any iron that may be present.

CHARACTERS.—Occurs in prismatic crystals, which may be large or small. The latter much resemble in appearance those of sulphate of magnesia, but their strong styptic taste will distinguish them from the bitter magnesian salt (*v.* p. 233): they redden litmus and effloresce in air.

ZINCI CARBONAS—CARBONATE OF ZINC, $ZnCO_3(ZnO)_2 2H_2O$, =341.4.

PREPARATION.—By adding carbonate of sodium to a boiling solution of sulphate of zinc, and drying the precipitate; if cold solutions be used, the precipitate is gelatinous. (The compound formed is really a hydrated oxycarbonate, as in the formula.)

CHARACTERS.—A soft, white powder, resembling magnesia, insoluble in water, tasteless and inodorous. The native impure carbonate (calamine, lapis calaminaris) was formerly officinal, but the pink powder sold under that name was almost always spurious, consisting of barium sulphate colored with iron.

ZINCI ACETAS—ACETATE OF ZINC, $Zn(C_2H_3O_2)_2 2H_2O$, =219.

PREPARAT ON, etc.—By dissolving the carbonate in acetic acid. Occurs in thin, lustrous, micaceous plates, having a sharp astringent taste.

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ZINCI VALERIANAS—VALERIANATE OF ZINC, $Zn(C_5H_9O_2)_2$, =267.

PREPARATION.—By mixing concentrated solutions of sulphate of zinc and valerianate of sodium.

CHARACTERS.—Occurs in brilliant scaly crystals, which have an odor of valerian, and a metallic taste; soluble slightly in cold water or ether, freely in hot water and in alcohol. It is liable to be contaminated with butyrate of zinc.

ABSORPTION AND ELIMINATION.—Soluble salts of zinc, such as the *chloride*, *sulphate*, and *acetate*, are readily absorbed, and pass into the blood probably as albuminates. The *oxide* and the *carbonate* are also dissolved to some extent by the acids of the gastric juice, and then slowly absorbed; independently of clinical evidence of this, the oxide has been detected by Schlossberger in the urine, and by Michaelis in venous blood.

Zinc does not seem to be deposited in the tissues in the same manner, or for so long a period, as mercury, lead, or copper, although recently Lechartier and Bellamy have detected it in the bodies of animals to whom the metal had been previously administered (*Medical Record*, i., 1877). The soluble salts are eliminated soon after being taken, but the insoluble ones are not found in the excretions until four or five days afterward (Michaelis). The metal passes out mainly by the bile and the intestinal secretions; in smaller amount by the urine.

PHYSIOLOGICAL ACTION (EXTERNAL).—The oxide and the carbonate of zinc, in powder, act mechanically as absorbents and sedatives. The sulphate and the acetate, in the solid state, act as efficient, but not very severe, caustics, if the epidermis be removed: in dilute solution they act as astringents. The chloride and nitrate exert a strongly caustic effect by virtue of their affinity for water, and their power of coagulating albuminous material; the former especially, being deliquescent, penetrates deeply into the tissues, and causes severe burning pain; the eschar produced is white and hard, and separates in five or six days; when formed from deep tissues it is of spongy character, but dry on exposed surfaces. Zinc chloride is a powerful disinfectant, and even in dilute solution proves fatal to germs, vibriones, etc.; according to Calvert's experiments, it is only equalled in efficacy by mercurial chlorides and the tar acids (*Lancet*, ii., 1873; *Medical Times*, ii., 1852, p. 101).

PHYSIOLOGICAL ACTION (INTERNAL).—*Digestive System.*—The oxide and carbonate, in doses of a grain and less, exert an astringent and somewhat sedative action on the gastro-intestinal tract, markedly lessening its secretions. The sulphate, in small, non-irritant doses, is still more astringent. All zinc compounds have a tendency to excite nausea and irritation of the stomach; the oxide and the carbonate, though tasteless, show this effect when given in doses of from 1 to 5 gr. and upward. The soluble salts have a styptic metallic taste, and the sulphate, in doses

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of 5 to 10 gr. and upward, acts as a prompt and thorough emetic without much nausea or prostration, though often with diarrhœa: this action is not purely a local one, because it is equally produced by intravenous injection of the salt. Emesis, however, is not a constant effect, for if the drug be taken at first in small doses and continued regularly, a certain tolerance is established, and then 10 to 20-gr. doses may be taken without disorder of the stomach. Caution is required in the continuance even of small doses, since they have been said to cause ulceration of mucous membrane, and ultimately symptoms like those of lead-poisoning, such as emaciation, anæmia, debility, fetor of breath, constipation, and colic, also tremor, paralysis, etc. Symptoms of acute irritant poisoning, such as pain, vomiting, convulsion, and collapse, have followed doses of 30 to 60 gr., and sometimes concentrated solutions have caused death (*Medical Times*, ii., 1862, p. 252), but the salt has rarely proved fatal, because of its being so soon rejected; persons have recovered after taking an ounce or even more.

The chloride is much more corrosive in character, and is unsuited for internal use—5 to 10 gr. have produced severe irritant symptoms. It has been a not infrequent source of fatal poisoning in the form of Sir W. Burnett's disinfecting fluid, which is an impure solution of it, somewhat oily in character, and either colorless or of yellowish tinge, from the presence of some ferric oxide: it has been mistaken for fluid magnesia, for mineral waters, and for pale ale, the fact of its frothing up when shaken contributing to its resemblance to the last-mentioned: one fl. oz. has been found to contain from 100 to 372 gr. of solid chloride (Taylor), 200 gr. (R. W. Smith), and less than that quantity has proved fatal, though not invariably.

Nervous System.—The oxide of zinc has been credited with a special action on the nervous system, of tonic character in small, but depressant in large doses. Dr. Marcet traced drowsiness to its use, and others have recorded giddiness after taking it, and generally depressed nervous and mental conditions from the prolonged continuance of large doses (*Medical Times*, 1858; *Medico-Chirurgical Review*, ii., 1861). In cases of ultimate recovery from the effects of large doses of zinc salts there have been, besides the gastric symptoms, signs of impaired nerve-power, with perversion of taste and smell, tremor, or partial paralysis. Exposure to fumes of the molten metal, as in the course of certain metallic castings, gives rise to a curious train of symptoms, mainly nervous, and commonly known as "brass-founders' ague," and including general malaise, tightness of chest, a cold stage with rigors, followed by a hot stage with profuse sweating. These symptoms may recur periodically for several days (H. Greenhow, quoted *Lancet*, i., 1863—*v.* p. 541).

Cutaneous System.—The internal administration of the oxide or other astringent zinc salts checks the secretions of the skin.

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SYNERGISTS.—The oxides of silver and of bismuth are much allied in action with oxide of zinc: henbane and belladonna promote its power of controlling perspiration (*v.* p. 312). The chloride of zinc resembles in corrosive and disinfectant properties the chloride of mercury, and both the chloride and nitrate are allied in action with other mineral caustics.

ANTAGONISTS.—The chemical antidotes in cases of poisoning by the corrosive compounds of zinc are lime-water, alkaline carbonates, and tannic acid; these should be given in mucilage or milk. Valerianate of zinc is decomposed by acids and by most metallic salts. Purgatives and diaphoretics interfere with the action of zinc salts.

THERAPEUTICAL ACTION (EXTERNAL).—*Lupus—Cancer, etc.*—The chloride of zinc was first introduced as a secret remedy for cancer by Canquoin in Paris in 1837, and was combined with sanguinaria in the paste of Dr. Fell, which had a temporary popularity (*Medical Times*, i., 1858, p. 11). Veiel recorded excellent results from its use in lupus (*Medico-Chirurgical Review*, ii., 1860), and it is certainly a very reliable escharotic. I have seen immediate improvement from it, in some very severe cases, especially of facial lupus and rodent ulcer. It has disadvantages in being deliquescent, and hence readily penetrating adjacent healthy tissues and disposing to hemorrhage, but when mixed with flour, zinc oxides, or better still with lime sulphate or gutta-percha, it becomes quite manageable. The nitrate of zinc, though not in such frequent use, has, perhaps, advantages over the chloride; according to Mr. Marshall, it penetrates deeper, and causes less pain: in lupus it was commended by Dr. Tilbury Fox, and I have had very successful results with it, generally using a paste made with equal parts of nitrate, flour, and mucilage spread on lint.

Both this salt and the chloride are equally applicable to all forms of strumous and syphilitic ulceration. Franchi reports arrest in some very severe cases of this kind, when acid nitrate of mercury, iodine, etc., had been tried, without success (*Gazette Méd. de Paris*, February, 1876). Maisonneuve used the chloride made into firm paste with flour in the form of flèches ("arrowheads"), which he thrust into incisions all round a morbid growth, thus destroying a zone of tissue and separating the tumor; but this process is more painful and prolonged than the use of the knife, and does not prevent recurrence better than an equally extensive incision.

Sir J. Y. Simpson advocated sulphate of zinc in powder as the best caustic for these maladies, whether affecting the uterus or other parts: it is simple, easily applied and managed, safe, efficient, fairly rapid in action (five or six days), and does not deliquesce. In cases where the epithelium was destroyed, he applied the anhydrous salt in fine powder or mixed with glycerin into a paste (1 oz. of sulphate to 1 dr. of glycerin). In other cases, *e.g.*, of cancer of the breast, he mixed the salt with sulphuric

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acid and scored the part with a quill at successive applications (*Medical Times*, i., 1857, and 1859); he records many good results, which were to some extent corroborated, but his practice has not been largely followed. Mr. Erichsen found it very painful (*Medical Times*, i., 1857, p. 238).

Warts—Nævi.—The strong chloride is useful for destroying warts and superficial nævi. Mr. Weeden Cooke has suggested a convenient mode of applying it, viz., by soaking lint in the deliquescent salt, drying it, and cutting off suitable pieces when required: if covered it will preserve its power for many weeks (*Medico-Chirurgical Review*, January, 1866).

Wounds.—Mr. C. de Morgan, and others, recommended the sponging of recent wounds, whether from accident or operation, with strong solutions of zinc chloride (20 to 40 gr. in the ounce), on disinfectant principles, *i.e.*, to destroy "germs" (*Lancet*, i., 1866; *Medico-Chirurgical Review*, January, 1866). This seems to have good effect in lessening risk of septicæmia, etc., but has in a measure been superseded by the more detailed and exact method of Lister. It is, however, still largely used, and is valuable in many cases, especially where Listerism cannot be carried out: it cleanses the wound and any old sinuses, and lessens and prevents suppuration. Some surgeons employ it especially after excision of malignant tumors.

Eczema—Erythema.—The oxide and the carbonate of zinc, and "calamine" (impure native carbonate), form useful sedative, absorbent, and protective powders for inflamed surfaces, and sometimes are indicated when serous discharge is present: they are generally mixed with ¼ or ½ part of a neutral powder, such as that of orris-root, starch, or magnesia. They may be used also suspended in mucilaginous liquids as a good lotion, *e.g.*, for erythematous acne of the face, or in the form of ointment mixed with oleic acid—oleate of zinc—(Crocker: *British Medical Journal*, i., 1879), or vaseline, or the benzoated lard of Mr. Erasmus Wilson: benzoated zinc ointment, when properly made, is an excellent application for irritative and eczematous conditions. A lotion containing 5 gr. of sulphate in the ounce, relieves the itching of eczema and other skin diseases, but is liable at first to cause some smarting.

Relaxed or Discharging Mucous Surfaces.—For ordinary relaxed or discharging surfaces, when astringents are indicated, the sulphate of zinc is one of the best: from 1 to 2 gr. in the ounce of distilled water is a usual strength, and combined with a stimulant, such as spirit of rosemary or lavender, this forms the ordinary "red lotion" of many hospitals, and is suitable for any indolent atonic ulcerations: sulpho-carbolate of zinc also forms a good detergent lotion (*Lancet*, ii., 1868, p. 763).

For catarrhal *throat affections* accompanied with deafness, Dr. Druitt finds zinc sulphate in solution act better than ordinary acid gargles, and Mr. Nunn reports similarly as to the chloride (*Medical Times*, i., 1857,

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pp. 210, 247): a spray containing this is excellent for relaxed pharynx and congested vocal cords.

In catarrhal *conjunctivitis*, and *otorrhœa*, collyria and weak warm injections of the same salts (2 gr. to the ounce of water) are useful, and 4 gr. to the ounce is a good strength for injection in *ozæna;* morphia, atropia, or carbolic acid may be combined with the astringent.

The chloride lotion is also valuable in *gonorrhœal* and *purulent ophthalmia*, and Mr. Hutchinson reports it as less painful than silver nitrate, and sometimes completing the cure when that remedy failed (*London Hospital Report*, 1867–68).

In *leucorrhœa* and *gonorrhœa*, injections containing 1 to 2 gr. of zinc sulphate or sulpho-carbolate to the ounce, are very suitable after the early acute stage has subsided (*Medical Times*, ii., 1870, p. 454, etc.); they are sometimes better combined with an equal quantity of lead acetate. As a general rule, the more acute the condition, the more frequently should a weak solution (½ gr. or less in the ounce) be applied, and as the inflammation becomes less or passes into a chronic stage, one or two applications daily of a double or treble strength are best. Some time ago I recommended to Dr. Ringer's notice the prescription of a very dilute injection of sulphate (1 to 2 gr. in the *pint* of water) to be used every hour or half-hour from the commencement of a gonorrhœal attack, and his experience supports mine, that this can arrest the disorder in twenty-four to forty-eight hours; care is required so as to avoid risk of pain and swelling of the testicles, *i.e.*, the injection must be used less often, or left off, if any such symptoms set in. A stronger solution (1 to 10 gr. in the ounce) is advisable, but used less frequently, in more chronic cases (Lloyd: *Lancet*, ii., 1850; W. Cooke: *Medical Times*, i., 1860, p. 127). The chloride, and indeed many other astringent salts, may be used in a similar manner with advantage.

Therapeutical Action (Internal).—*Narcotic and other Poisoning.*—Zinc sulphate is a good emetic for cases of this kind: 10 gr. in warm water is an average dose, but 20 gr. is the amount preferred by many practitioners; if the mouth be firmly closed, it may be administered by a tube passed through the nose to the gullet, or by the stomach-pump through a gag, and if the larger dose be used, its after-rejection must be secured. When an emetic is given by the stomach, its bulk has an effect in securing the result: thus, the greater quantity of warm water that can be given with the zinc sulphate the better it will act: time also makes a difference, for smaller doses given slowly have acted better than large ones quickly swallowed. In some cases a few grains have been given by intravenous injection, and have produced emesis.

Gastralgia—Diarrhœa.—Prof. Gubler, having remarked the analogous effects of the oxides of zinc and of bismuth, suggested the substitution of the former when expense was an object, and experience has

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proved that the zinc compound will often act in an extremely satisfactory manner in relieving gastric pain, especially when this is followed by diarrhœa of undigested food; it has, however, more tendency to nauseate than the bismuth salt. The dose should commence at 1 gr., and not exceed 3 gr., and should not, as a rule, be given on an empty stomach.

In *dyspepsia* connected with oxaluria, Bartholow has found the sulphate useful, and Gillespie recommends it (*Boston Journal*, May, 1868).

Dr. Brakenridge, of Edinburgh, was one of the first to draw attention to the value of zinc oxide in *infantile diarrhœa* (*Medical Times*, i., 1873), and I have, in common with many others, found it an efficient and non-irritant astringent.

In *chronic* diarrhœa, and even in *dysentery*, the oxide has acted very favorably (*Bulletin de Thérapeutique*, March, 1877), but the sulphate has more decided powers.

Bronchorrhœa.—Excessive secretion from the bronchial tubes is controlled by the oxide and by the sulphate of zinc (Barlow).

Hyperidrosis.—I can entertain no doubt of the power of zinc oxide to control excessive sweating in phthisis and other exhausting diseases, although it has been denied by some observers. Dr. T. Thompson, one of the first to record this effect, found it increased, as we should expect, by conjunction of the zinc with henbane extract—he prescribed 4 gr. of each substance (*Medical Times*, i., 1854, p. 190); and W. Curran and others have corroborated his observations (*Lancet*, i., 1854, ii., 1868). I generally order 1 or 2 gr. of the oxide with the same quantity of extract of henbane, to be taken at bed-time, and again in the course of the night if necessary.

Epilepsy.—The value of zinc salts in disorders of the nervous system has been much disputed, some physicians, as M. Herpin, recording extraordinary results from them, and others, as M. Gubler, denying to them any power.

There can be little doubt that the high estimate formed by M. Herpin of the efficacy of the oxide, and later of the lactate of zinc, in epilepsy, is unfounded—no other observer has verified his results—at the same time we cannot deny altogether their efficacy in some cases. Dr. Wilks has seen benefit from the oxide (*Medical Times*, i., 1869, p. 84), and Dr. Sieveking records successful results, though he does not value it highly. Dr. Russell Reynolds has known it serviceable, and Dr. Radcliffe, noting its effect in causing anæmia, suggests that it might best be tried in markedly congestive cases (*Lancet*, i., 1863). Others have thought it more applicable when the epilepsy was complicated with gastric disorder, and others again have seen the best results from it when used in conjunction with bromides or digitalis (*Lancet*, ii., 1868; *Medical Times*, ii., 1874, p. 481).

Charcot has observed benefit from the bromide of zinc (*British Medi-*

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cal Journal, November, 1877), but Dr. Gowers, in his recent lectures, considers that salt of little value, and has found it badly borne. The oxide, however, in his experience, proved sometimes useful, relieving three cases out of ten submitted to it (*Lancet*, i., 1880, p. 553).

Chorea.—There is much evidence as to the value both of oxide and sulphate of zinc in this malady, more perhaps in favor of the latter; it requires to be given in gradually increasing doses up to 15 to 20 gr. (Barlow). In recording many cases, all of which derived some benefit, Mr. Marsh, of the Children's Hospital, remarks that no definite indication for the sulphate could be verified, but that a harsh, dry skin became soft during its administration (*Lancet*, ii., 1871); it was well borne. In chorea affecting *strumous* children, I can speak well of the iodide of zinc. Dr. Barlow was the first to recommend it (*Medical Times*, ii., 1857).

Chronic Alcoholism.—Dr. Marcet made many observations on the treatment of this condition, and published a special essay to illustrate the value of zinc oxide in controlling the unsteadiness and the tremor which are its usual accompaniments ("Chronic Alcoholic Intoxication," London, 1860; *Lancet*, i., 1859). Dr. Anstie accorded some, but not so much, value to the drug in the same conditions.

In *Hysteria* and *Debility*, if anæmia be not extreme, zinc salts often prove useful, but more especially when combined with other nerve-tonics: thus, Dr. Barnes speaks very favorably of zinc with phosphoric acid (phosphate of zinc) (*Lancet*, i., 1858, p. 119), and has recently re-stated his opinion as to its value in convulsive diseases of women (*Lancet*, i., 1873, p. 621). Vigier finds the phosphide of zinc acts more quickly than phosphorus itself (*Bulletin*, January, 1876), and the valerianate, although decried by many observers, certainly relieves in some cases. Zinc oxide may be combined with camphor, galbanum, sumbul, etc.

Spasmodic Cough—Asthma.—Both the oxide and the sulphate of zinc, especially in conjunction with belladonna, have been found to relieve spasmodic cough, whooping-cough, etc. (Fuller: *Lancet*, ii., 1860). In the intervals of spasmodic asthma, they are given as prophylactics (Symonds: *British Medical Journal*, i., 1868). The valerianate has been successfully used for obstinate hiccough and for hysterical cough (G. Harley: *Medical Times*, ii., 1863), but although of some value, is uncertain in its action. In laryngeal spasm, sometimes, 5 to 6-gr. doses will succeed when smaller ones fail (*Medical Times*, i., 1858, p. 475).

Nervous Headache—Neuralgia.—The valerianate is valuable in nervous headache, and it is especially useful for cases of neuralgia connected with uterine derangement.

Tremor.—In tremor connected with mercurial and arsenical poisoning, Guéneau de Mussy found phosphide of zinc effective (*Lancet*, i., 1876, p. 208). I have tried it in the tremor of sclerosis, but without result.

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Rheumatism.—Among the rarer uses of zinc salts may be mentioned that of the cyanide in articular rheumatism; it was strongly commended by Luton, as relieving pain and lowering vascular excitement (*Bulletin*, January, 1875). Other observers find it also of some, but not definite, value; it is apt to cause headache (*Medical Record*, i., 1877).

PREPARATIONS AND DOSE.—*Zinci oxidum:* dose, 1 to 10 gr. or more, in pill or powder. *Unguentum zinci:* made with oxide of zinc and benzoated lard. *Zinci carbonas:* dose, 1 to 10 gr., in pill or powder. *Zinci sulphas:* dose, as a tonic or astringent, 1 to 5 gr. or upward, in pill or solution; as an emetic, 10 to 30 gr.; for an injection or lotion, from 1 to 10 gr. in the ounce of water. *Zinci acetas:* dose, 1 to 2 gr. as a tonic; 10 to 20 gr. as an emetic; as an injection or lotion, 1 to 10 gr. to the ounce of water. *Zinci valerianas:* dose, 1 to 5 gr. and upward. *Zinci chloridum:* dose, $\frac{1}{2}$ to 2 gr. *Pasta zinci chloridi:* made with flour and mucilage. *Liquor zinci chloridi*, British Pharmacopœia (contains about 36 gr. in the fluid ounce, *v.* p. 308), not used internally. *Zinci nitras* (not officinal): used as a caustic in paste.

[PREPARATIONS, U. S. P.—*Zinci acetas; Zinci carbonas præcipitata; Ceratum zinci carbonatis* (1 part to 5 of ointment); *Zinci chloridum; Liquor zinci chloridi; Zinci oxidum; Unguentum zinci oxidi* (80 gr. in 1 oz.); *Zinci sulphas; Zinci valerianas.*]

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